Engineering Library

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ENGINEERING:

An Illustrated Weekly Journal.

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See Advertisement page 26. 9091

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See Advertisement page 66, Oct. 7. 2402

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See Advt. Page 92, Oct. 7.
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9741

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THE COMMISSIONERS OF HIS MAJESTY'S WORKS, &c., are prepared to receive

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a.m. on Monday, 24th October, 1921, for the SUPPLY of ELECTRIC LAMPS. Forms of Tender, &c., may be obtained on application to the CONTROLLER OF SUPPLIES, H.M. Office of Works, &c., King Charles Street, Westminster, London, S.W. 1. S 303

SIAMESE STATE RAILWAYS.

Tenders are Invited for the

SUPPLY of 20 BOGIE RAIL TRUCKS.
Specifications and Drawings may be obtained against payment of £1 from Messrs. C. P. Sandberg, 40, Grosvenor Gardens, London, S.W. 1.
Sealed Tenders, with the inscription "Tender for 20 Bogie Rail Trucks 2434," must be forwarded to the undersigned at whose office in the City of Bangkok, Siam, they will be received up to Two p.m. on the 16th January, 1922, at which place and hour the Tenders will be publicly opened and read.
Right is reserved to reject any or all Tenders and to accept any Tender which in the opinion of the undersigned is to the best interests of the Siam State Railways.

PURACHATRA,
Commissioner General of Siam State Railways.
Department of State Railways,
Bangkok, September, 1921. S 295

THE BURMA RAILWAYS COMPANY, LIMITED.

The Board of Directors of the Burma Railways Company, Limited, are prepared to receive

Tenders for the Supply of—

BRIDGEWORK (Six 100 ft. spans).
For each copy of the Specification a fee of 20s. will be charged, which fee is not returnable. Tenders enclosed in sealed envelope addressed to the "Chairman and Directors" and endorsed "Tender for Bridgework," must be delivered at the Company's Offices not later than Twelve noon, on Wednesday, 26th October, 1921. The Directors do not bind themselves to accept any or the lowest Tender and reserve the right to divide the order.

By Order of the Board,
F. C. FRANKS,
Secretary.
199, Gresham House,
Old Broad Street,
London, E.C. 2.
13th October, 1921. S 310

COUNTY BOROUGH OF WALLASEY,

SEACOMBE FERRY IMPROVEMENTS.

The Corporation of Wallasey invite

Tenders for the Carrying Out

of that portion of the above Work, denominated work "B" NEW FLOATING ROADWAY, and Work "C" OUT FOR NEW FLOATING ROADWAY, and works in connection therewith, in accordance with the detailed Plans and Specification of Messrs. Wilton & Bell, Consulting Civil Engineers, Westminster Chambers, 1, Crosshall Street, Liverpool, at whose office copies of the Specification and Drawings may be seen.
Contractors desiring to obtain copies of Plans and Specification and Schedule of Quantities, may do so on payment of a fee of £3 3s. for each work, or of £3 3s. for the two Works, which fees will not be returnable.
Tenders on the Form of Tender provided must be delivered to the undersigned in a sealed envelope endorsed "Tender for Seacombe Ferry Improvements, Works B and/or C," not later than Twelve Noon, Saturday, November 5th, 1921.

GEO. LIVSEY,
Town Clerk.
Town Hall, Wallasey.
7th October, 1921. S 247

THE MINISTRY OF PUBLIC WORKS, EGYPTIAN GOVERNMENT, are calling for

Tenders for the Supply of

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The Plant to include four Diesel or Semi-Diesel Engines, each directly coupled to a Turbine or Centrifugal Pump, with all necessary pipes, etc.
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Queen Anne's Chambers,
Westminster, S.W. 1.

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Service of an Engineering

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DIRECTORATE OF METALLURGICAL RESEARCH.
ASSISTANT I.

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Research Department,
Royal Arsenal,
Woolwich,

from whom the conditions of Employment may be obtained.
S 279

CITY OF BIRMINGHAM ELECTRIC SUPPLY DEPARTMENT.
ASSISTANT RESIDENT POWER STATION ENGINEER AND FOUR POWER STATION SHIFT ENGINEERS.
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ONE ASSISTANT RESIDENT POWER STATION ENGINEER, Minimum Salary in accordance with National Joint Board Schedule, applicable to Grade 5, Class G.
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Candidates must have had a sound theoretical and practical training in Electrical and Mechanical Engineering and be thoroughly experienced in the operation of a modern Power Station. Preference will be given to Corporate Members of the Institution of Electrical Engineers.
The successful candidates will be required to undergo an approved medical examination and contribute to the Corporation Superannuation Scheme.
Forms of application for the above appointments may be obtained from the undersigned, and when completed should be sent to these offices with copies of not more than three most recent testimonials as to experience, ability and character. Applications endorsed "Assistant Resident Engineer," or "Shift Engineer," as the case may be, must be sent in not later than Monday, October 31st, 1921.

H. J. JENNINGS, Secretary.
14, Dale End, Birmingham.
5th October, 1921. S 278

PORTSMOUTH MUNICIPAL COLLEGE.

Applications are Invited for

the APPOINTMENT of a WORKSHOP INSTRUCTOR, fully qualified in both Wood and Metal work. Candidates should hold diplomas of the City and Guilds of London Institute and preference will be given to one with trade experience. Salary according to qualifications and experience. —Further particulars and Forms of Application may be obtained from the SECRETARY, to whom applications should be returned at once, accompanied by copies only of not more than three recent testimonials. S 322

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Tea Company HAS a VACANCY on its European staff for a YOUNG GENTLEMAN (age 22-24 and unmarried), with Engineering Experience to become a Tea Planter on its Gardens in Assam. The position would be under a three years' agreement commencing from the date of arrival at the Gardens, and salary for the first year would be at the rate of Rs. 250 a month, rising by annual increments of Rs. 50 a month to Rs. 350 a month in the third year. First class passage to the Garden would be paid by the Company.—Applications should be addressed to BOX "ASSAM," care of Davies & Co., 95, Bishopsgate, E.C. 2, and should contain full particulars as to age, education and engineering experience. S 304

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Thoroughly Experienced and Energetic BLAST FURNACE MANAGER for up-to-date Mechanically-charged Furnaces, well versed in production of Basic and Foundry Irons from lean ores.—Apply, stating age, experience and salary required, to JOHN LYSAGHT, Ltd., Normanby Park Steel Works, Scunthorpe. S 309

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QUIRED by the Government of the Gold Coast for service as Executive Engineers in the Public Works Department, for two tours each of 12-18 months, with prospect of further employment. Salary £480 rising by annual increments of £30 to £720 a year and thereafter by £40 to £960 a year with an outfit allowance on first appointment of £60. Married men will also be paid, during 1921, a special allowance at the rate of £60 a year which may be continued. Free single quarters and first class passages. Liberal leave in England on full salary.
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SERVICES of a HEAD DRAUGHTSMAN with good experience of Pump work, Steam Engines, and Hydraulic work. State qualifications, age and salary.—Replies will be treated confidentially, and should be addressed, CHAIRMAN, Tangyes Limited, Cornwall Works, Birmingham. S 286

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Manchester area, Structural Draughtsman. Must have good practical and theoretical experience. State salary and training. Age not under 25.—Address, BOX 46, Wheeler's Advertising Agency, Manchester. S 300

Two or Three First-class

DRAUGHTSMEN REQUIRED for Aeronautical work. A wide engineering experience, including shop training, with some experience of Aeroplane work necessary. When applying give full particulars of training, experience and salary required.—Address, S 246, Offices of Engineering.

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A thoroughly experienced Designer of Semi-Diesel Automobile and Aero types, is OPEN for ENGAGEMENT with good class firm. Highest references. Would undertake to design engines of either type for firm wishing to take up this speciality or to embody improvements in their present designs.—Address, S 273, Offices of Engineering.

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A.M.I.C.E., with 16 years' experience, DESIRES POST.—Address, S 314, Offices of Engineering.

Young Man Requires Experi-

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THE ROTARY PIERCING MACHINE FOR STEEL AND COPPER BILLETS.

By C. E. Davies, A.M.I.Mech.E.

(*Concluded from page* 496.)

Regarding the general theory of the rotary piercer, as set forth in the preceding translation, while the explanation given is most ingenious and is probably the most satisfactory theoretical analysis of the very complicated action of the inclined roll machine, some of the conclusions may not be accepted as proved.

The main principle which has been elucidated, namely, the dependence of the hole formation on the value of the torsion angle, is no doubt correct, and indicates a very sound guide for the proper design and working of the piercer. At the same time any practical experience of the process will cause the question to be raised, whether the formation of the interior hollow follows very closely the section illustrated in Fig. 14, page 495 *ante*. In this figure, the hollow is shown to start immediately the end of the billet is gripped by the rolls, whereas, in the writer's opinion, it commences much later, and the breaking away from the centre is less gradual.

A most important condition to be observed in the setting of the rolls, which is clearly proved in practice, is that the necessary reduction in diameter, from the original billet, is obtained by the rolls. This is, of course, the same thing, in effect, as the increase in the value of the torsion angle, but it is rather more obvious (as pointed out in section 6, page 495 *ante*), that the area of the section passing the "throat" of the pass, must be equal to the area of the section of the finished shell.

At first sight, it would appear paradoxical, to state that an increase in "pinch," or reduction in diameter, of the billet, would reduce the power required by the piercing operation, but from the foregoing, this is clearly explained, and it is well known, that when a small reduction in diameter is found to call for more power than is available to drive the machine, by setting the rolls more closely together, thereby increasing the reduction in diameter, the piercing operation may be completed satisfactorily, with a considerable economy in power consumption.

There is, of course, a limit to the maximum reduction possible, and consequently the piercing effect, with any given machine. This limit being set by the amount of taper of the conical roll barrel at the side of entry, with any given difference in the maximum and minimum roll diameters D, and D_0, there is a maximum reduction possible in billet diameter, which is $D - D_0$; moreover, the reduction must be less than this limiting value, for the reason that the rolls must be set sufficiently far apart, to allow the billet to enter easily between the rolls, and become firmly gripped by them.

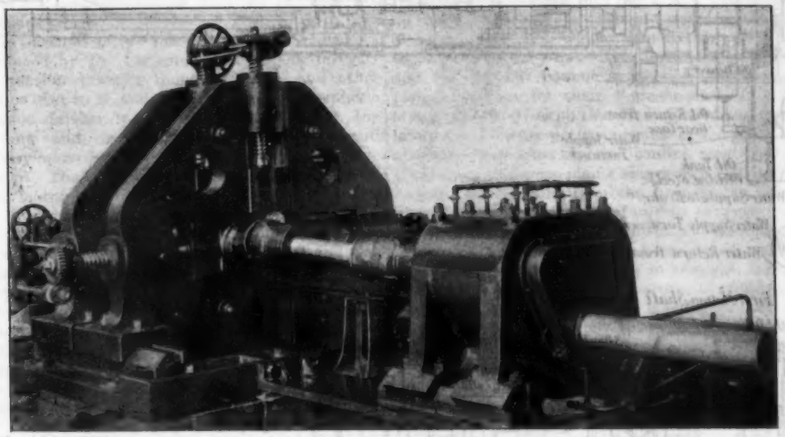


Fig. 21. Piercing Machine, Constructed by Messrs. W. H. A. Robertson and Co., Limited, Bedford; View from Driving End.

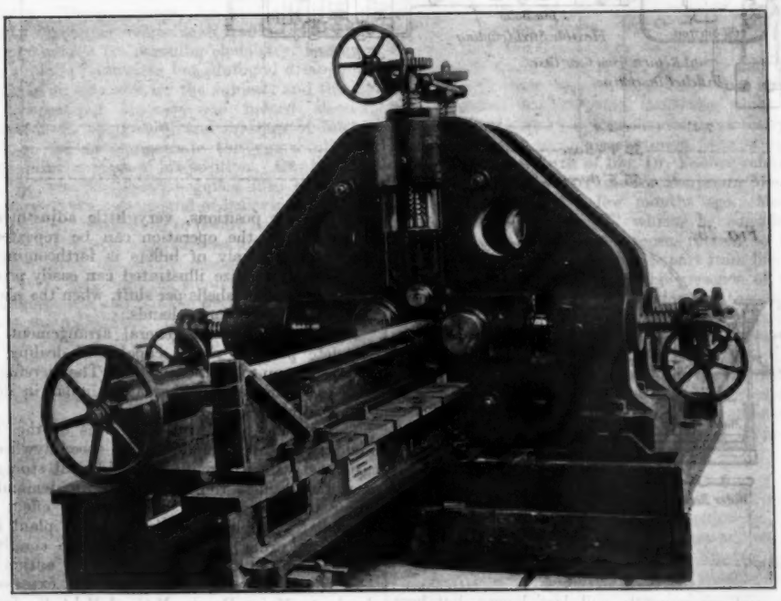


Fig. 22. Piercing Machine, Constructed by Messrs. W. H. A. Robertson and Co., Limited, Bedford; View of Feed Side.

Although much experimental work has no doubt been carried out on these machines by large users, the results obtained are naturally confidential and in the nature of trade secrets, so that there is still scope for systematic research work.

One of the most important points, still requiring experimental investigation, is the determination of the best proportion of wall thickness in relation to the billet diameter. Experience has shown that there is a maximum and minimum diameter of hole which can be pierced in any particular size of billet, and that a small billet may be pierced to give a thinner wall than is possible with one of larger diameter; but the practicable range of wall thicknesses is not great and the actual limiting dimensions in any case depend very considerably on the nature of the metal dealt with.

During recent years, more and more powerful machines have been constructed and put into operation successfully, so that pierced shells are obtained of dimensions previously considered impossible. This is, however, merely a question of power and adequate strength in machine design.

Another point worthy of comment is in relation to the quality of steel which may be pierced. As repeatedly stated, by the author of the German article, only a very homogeneous quality of steel can be satisfactorily pierced in the Mannesmann piercer, and at first it was thought that only the very best Swedish steel could be dealt with, but now while the best results are still obtained with specially homogeneous metal, shells can be successfully obtained from any good mild steel and even from special alloy steels.

The investigation of the action of inclined rolls on conical ingots (section 4), is interesting, but it is somewhat surprising to note the conclusion that it is preferable to enter the thick end of the ingot first between the rolls; as the calculated example would appear to prove the opposite. It is understood, however, that the existence of a spongy and flawed condition at the top, or small end, of the ingot, gives considerable assistance to the piercing operation during the last and most difficult part of the pass. With forged and rolled billets which are slightly taper, it would seem best to present the thin end to the rolls at entry.

With regard to the actual design and construction of the Mannesmann-type piercing machine. Only a few years ago it was stated in the technical press, that it was not possible to obtain a British-made rotary piercer, actually at the time this was not strictly true, and now these machines are regularly built to standard designs by well-known British firms specialising in rolling-mill machinery.

The following description is that of a British-made rotary piercer which is illustrated by Figs. 21 and 22. This machine is fitted with rolls 14½ in. maximum diameter, and is designed to pierce copper or steel billets up to 4 in. diameter. Referring to Figs. 21 and 22, it will be seen that the three rolls are carried in bearings, which are contained by sliding pieces or chocks. These chocks can be adjusted along the machined slides in the housings, adjustment being effected by means of hand wheels operating, through machine cut worm gearing, forged steel screws which work in phosphor-bronze nuts in the housings. Similar adjustment is provided for both the main side rolls and for the top roll. The housings are massive iron castings, with feet machined to an inverted "vee" section, to fit bedplate, ensuring thereby accurate alignment.

The rolls themselves are forged from a special quality of steel which will maintain a sufficient degree of hardness, while working on the hot billets. Fig. 22 shows the feed side of the mill, with the driving gear to the rolls, the drive being transmitted from the main driving shaft by three double helical steel pinions. These pinions are mounted in a totally-enclosed gear-box or housing, which forms an oil bath for the gearing. The three shafts run in specially-designed bearings, provided with forced lubrication, the waste oil being collected and returned to the supply tank.

The two main rolls are driven from the two upper

GENERAL ARRANGEMENT OF MOTOR-DRIVEN PIERCING MACHINE.

CONSTRUCTED BY MESSRS. W. H. A. ROBERTSON AND CO., LIMITED, ENGINEERS, BEDFORD.

Fig. 23.

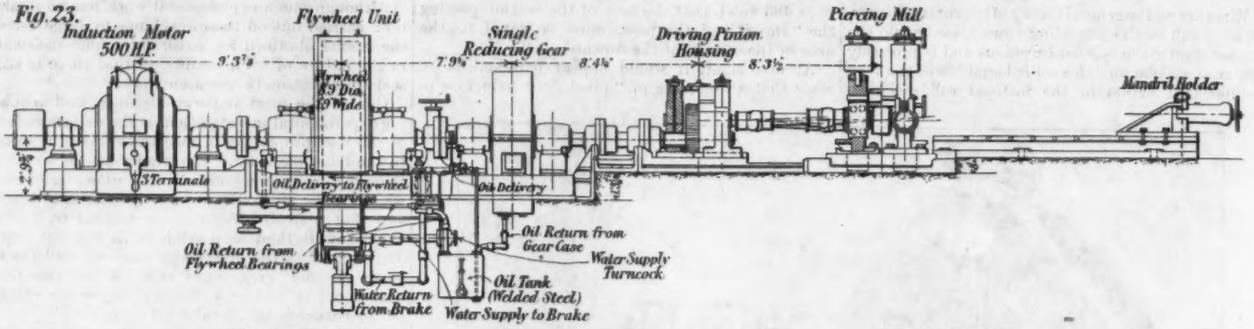
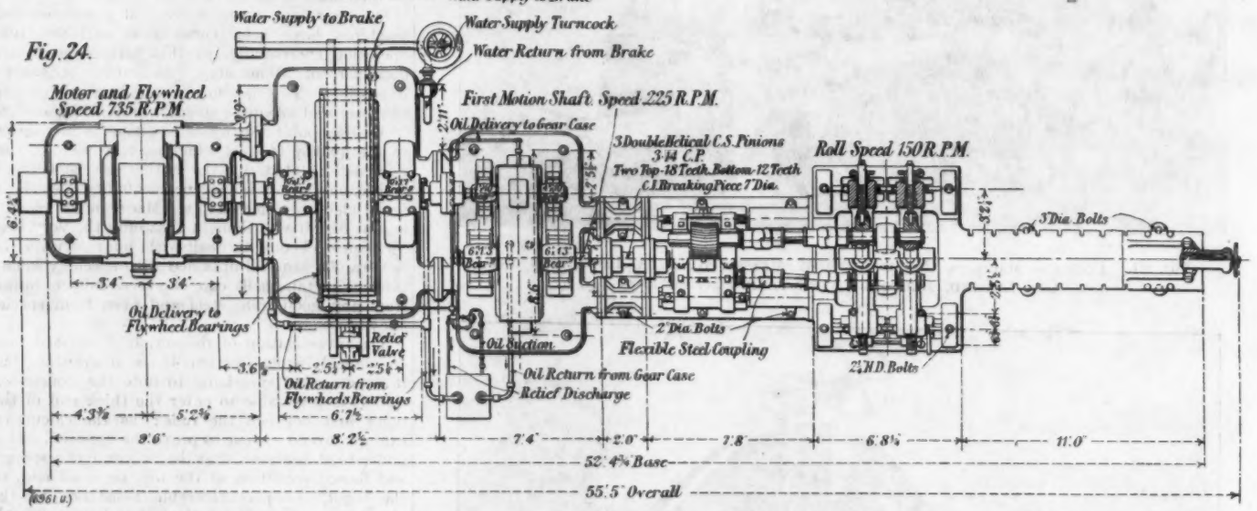


Fig. 24.



pinion shafts through steel coupling spindles, which have universal couplings of cast steel, at each end, this arrangement allows for the angular position of the rolls, in relation to the pinion shafts, and for their horizontal adjustment to suit varying billet diameters. Between these coupling spindles, is fitted a guide trough, to receive the heated billet, and to enter it correctly between the rolls, this guide is mounted on a steel girder which runs through the machine, carrying on the other side (see Fig. 21) a support for the piercing plug shaft.

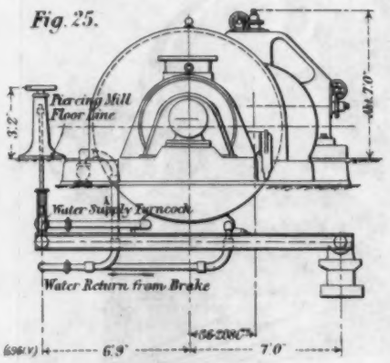
The plug mandrel, or shaft, is clearly shown in Fig. 21, supported at the correct height by a sliding guide piece, and the thrust on the plug is taken by a ball thrust bearing, contained in the mandrel holder, which is hinged to a bracket bolted to an extension bed.

The handwheel at the end of the mandrel holder operates a screw, which gives sufficient end adjustment to bring the plug into the correct position in relation to the rolls. The provision of a ball thrust bearing for the mandrel is, of course, to allow the piercing plug to revolve freely with the billet, between the rolls, and as this speed of rotation may easily be from 350 r.p.m. to 400 r.p.m., some means of minimising the friction at the thrust bearing is necessary.

The actual thrust pressure is not great, with proper adjustment of the rolls and plug, and there is some difference of opinion, as to whether it is essential to provide for the rotation of the plug. Machines are found to operate in a perfectly satisfactory manner with the mandrel fixed, and from one point of view it is an advantage to avoid the complication of the thrust bearing altogether.

It is stated in the German article translated, that by allowing free rotation of the plug, the resistance of the plug is reduced, but the difference is scarcely appreciable, and careful experiment is necessary before a definite conclusion can be arrived at on this question. It is probable that a rotating plug wears less, and consequently will last longer, but here again comparative data are not available.

Fig. 25.



As will easily be understood, the thrust bearing for the rotating mandrel requires very careful designing in the larger machines, and for this reason machines, heavier than that illustrated here, are frequently made with a fixed support for the plug bar.

The method of the operation is fairly obvious, a solid billet, previously heated to the required temperature, is placed in the guide and pushed forward until gripped by the rolls. On the outgoing side the hollow shell produced runs out on to the mandrel bar, pushing the mandrel support before it. As the finished shell is left hanging on the mandrel, the reason for hinging the mandrel support is explained. By removing a pin this support is swung clear, and the finished tube easily removed.

With billets, uniform in diameter, temperature and quality, when the rolls and plug are once set in their correct positions, very little adjustment is required, and the operation can be repeated as long as the supply of billets is forthcoming. A machine of the size illustrated can easily produce 8 tons of finished shells per shift, when the plant is operated by experienced hands.

Fig. 23 shows the general arrangement of a complete piercing plant, capable of dealing with steel billets up to 6 in. diameter. The piercing mill itself is by the same maker and similar in design to that already described in detail.

The driving gear from motor, is of the most modern type, and includes a high-speed flywheel, of cast steel, which provides for sufficient storage of energy to reduce the fluctuations in demand for power to a minimum. The flywheel effect was particularly ample in the case of the plant illustrated, in order to comply with the conditions specified by the local electricity supply authorities.

In conclusion the writer wishes to express his thanks to Major Royds, M.C., A.M.I.C.E., for his valuable assistance in translation of the German article, and to Messrs. W. H. A. Robertson and Co., Limited, Bedford, for their permission to publish illustrations and drawings of piercing machines of their design and manufacture.

THE BRITISH ASSOCIATION.

(*Concluded from page 470.*)

SECTION B.—CHEMISTRY.

The success of the Chemical Section is bound up with the recognition of the fact that the British Association is the proper institution for discussions of chemical problems bearing upon the general advance of science rather than for the discussion of strictly chemical detail. Undoubtedly one of the parent sciences, if not *the* parent science—physicists claim that honour more than ever after having disclosed the structure of the atom—chem-

istry is closely related with all the branches of science with which the Association deals, including economics, education and anthropology. But the recognition of the importance of broad problems points in the first instance to co-operation between members of Section B with the mathematicians, physicists and engineers of Sections A and G, and, further, with the physiologists and biologists. The latter relationship was the keynote of Dr. M. O. Forster's presidential address at Edinburgh and also of the joint discussions with the physiologists of various papers.

The discussion on the structure of molecules introduced by Dr. Langmuir and papers on surface tension brought members of A and other sections over to B, and the question of atmospheric pollution further interested engineers, while the economic and chemical aspects of the dyestuff industry were dealt with in a generally-instructive manner. The 13 papers on the agenda were disposed of in morning sittings, the afternoons being left free for excursions to works and laboratories, including the brewery of Messrs. Younger and Son, the works of Messrs. Duncan, Flockhart and Co., manufacturing chemists, of the North British Rubber Company and of the Broxburn Oil Company.

Dr. Martin Onslow Forster, F.R.S., late professor of organic chemistry at the Imperial College of Science, South Kensington, was the president of the section, and Professor Cecil A. Desch, recorder, with Drs. H. McCombie, E. H. Tripp and J. E. Mackenzie as secretaries.

The Laboratory of the Living Organism.

Before proceeding to his main subject, Dr. M. O. Forster referred to the reasons which have been urged in recent years for stimulating the study of chemistry. Those reasons, he said seemed at present to be either defensive or frankly utilitarian. The only motive for pursuing chemistry, however, which promised anything but profound disappointment, was an affection for the subject, and though the prospect of success was indeed slender, enthusiasm for the beauty and mystery of Nature would go far to compensate the young chemist for the disadvantages of his position. On the other hand, he who had been beguiled into embracing chemistry on the sole ground of believing it to be a "good thing," would either desert it expeditiously or starve and shower purple curses upon his advisers. In one respect chemistry resembled the measles which every boy and girl should have. Whilst it was unnecessary and most undesirable, however, to present the subject as "if every boy and girl were going to be a chemist," it was most important to present it in such a manner that every educated citizen might realise the intimate part which chemistry played in daily life. Not only did chemical principles underlie the operations of every industry, but every living organism was during each moment of healthy life a practical organic and physical chemist. No other branch of knowledge could appeal for attention on comparable grounds.

Before we reached the breakfast table, Dr. Forster proceeded, the smell of frizzled bacon worked wonderful chemical processes in our bodies. The mouth-watering was known to the physiologists as a "psychic reflex," the various forms of which were akin to demonstrations the chemical philosopher made in his laboratory, but were hopelessly inimitable. The minute cells, of which our bodies were co-ordinated assemblages, possessed powers of synthetic achievements, compared to which the classical syntheses were but hesitating preliminaries. Carbohydrates, alkaloids, glucosides and purines, complex as they appeared, represented only the molecular *debris* strewing the path of enzyme action and photochemical synthesis, whilst the enzymes themselves, so far from having been synthetised, had not even been isolated in the purified form. The starch, fat and proteins of our toast, butter and bacon were rendered transmissible to our blood by transformations otherwise unattainable in our laboratories, and if masters of chemical craft like Emil Fischer* had isolated the resultant individuals, we could hardly yet visualise, and much less imitate, the concurrent syntheses. The perpetual elaboration of fatty acids from carbohydrates, of proteins from ammo-acids and of zymogens and hormones as practised by the living body, were beyond the comprehension of the biochemist.

Though Dr. Forster could outline many triumphant successes due to biochemical research, his address might be said to emphasise the final admission which chemists generally have to make:—"We do not know, and we cannot do likewise"—though Dr. Forster did not put it so. Plants build up their tissues from carbonic acid, water and nitrogen, materials which animals are powerless to utilise until they have been assembled by plants, and the chemist cannot synthetise starch which plants produce by their "greenness." It looks almost an odd triumph that R. Robinson and others lately succeeded in preparing some of the poisonous alkaloids (tropinone, piperine, coniine, nicotine, &c.). If the growth of green plants hinges upon chlorophyll, human life depends upon the hæmoglobin of the blood corpuscles. The relationship between these has mainly been studied by Willstätter. Chlorophyll is a magnesium compound, hæmoglobin an iron compound; chlorophyll forms in sunlight, but not in the absence of iron; the natures of chlorophyll and hæmoglobin have been elucidated, but the mechanism by which they act remains unrevealed. The chemistry of the anthocyans, the pigments of blossoms and fruit, has been investigated successfully within the last decade by Willstätter and by Everest. As regards yeast the nucleic acid of yeast forms a connecting link between the undefined molecules of living protein and the crystallisable products of katabolic disintegration. But we do not yet understand how the yeast cell works, though many parts of the machinery have been recognised. The practitioners of micro-biochemistry produce hydrogen, carbon dioxide, formic acid, various alcohols and their acids, glycercol, &c.; "they work for 24 hours a day unless underfed and dissatisfied with their conditions, but microbes refuse to be beguiled into accepting molecules which do not harmonise with their own enzymic asymmetry."

With respect to photosynthesis, the energy problems and the birth of life, Dr. Forster referred to the Biochemistry of Professor Benjamin Moore, of Oxford, published a few months ago. Moore speaks of "biotic energy," which, he considers, "is just as closely, and no more, related to the various forms of energy existing apart from life, as they are to one another; in the presence of the proper and adapted energy transformer, the living cell, that biotic energy is capable of being formed from or converted into various other forms of energy according to the general laws of energy. The most characteristic feature of biotic energy, distinguishing it from all other forms, is the power which it confers upon the specialised transformer to proliferate." This definition, we are afraid, hardly helps us greatly.

Biochemistry.

Biochemical problems were further dealt with, from the chemical standpoint, in a paper by Professor R. Robinson, F.R.S., of Liverpool, on the "Genesis of Plant Pigments and Related Substances," and from the physiological standpoint in a joint discussion with Section I, Physiology, on Biochemistry in connection with papers by Professor W. Gowland Hopkins, F.R.S., on "Oxidations and Oxidative Mechanisms in Living Tissues," by Dr. C. Lovatt Evans and others. The vitamines (particularly studied by Professor Hopkins), the mysterious constituents of some foods, such as fresh vegetables, the husks of rice, yeast, &c., which, though nowhere present except in very minute proportions, seem to be essential to make animals thrive and to keep off diseases like beri-beri and scurvy, have as yet no chemistry, and were not discussed in Section B.

Synthesis of Formaldehyde and Carbohydrates.

The synthetic building up, under the influence of light, of the sap and tissues of plants, from the carbon dioxide of the air and from water is generally believed to proceed *via* formaldehyde H.COH, which is supposed to be the first product formed by the plant. But the actual presence of formaldehyde —the essential ingredient of many antiseptics—in growing leaves is very doubtful, and it is assumed that the formaldehyde is rapidly polymerised into carbohydrates, in the first instance into sugars of the reducing type; cane sugar is not of that type. In their paper on the "Synthesis of Formaldehyde and Carbohydrates from Carbon Dioxide and Water," Professor E. C. C. Baly, F.R.S., Drs. M. Heilbronn and W. F. Barker, of Liverpool, showed that under the influence of ultraviolet light of λ 200 $\mu\mu$ formaldehyde is indeed formed, and that it is polymerised into some sugars by radiations of greater wave-length, 290 $\mu\mu$, an equilibrium condition being set up between CO_2, formaldehyde and the sugar. In the presence of certain coloured metallic salts (of uranium, iron, copper) this photosynthesis can be effected in visible light, in the laboratory; in the plant such salts are missing, but the chlorophyll seems able to supply the photocatalyst necessary for the two reactions, even when the concentration of CO_2 is very small. Formaldehyde then would be an intermediate product, not likely to be found in the leaf. The discussion of the communication on the formaldehyde problem which, Dr. Forster and others pointed out, has occupied the attention of the great chemists for half a century since Baeyer's days, showed that much remains controversial. So far the polymerisation stops at the sugar stage; there is doubt about the identity of the sugars, and while magnesium carbonate is actually formed in the plant from the magnesium in the chlorophyll, Dr. E. J. Russell stated that magnesium salts did not stimulate photosynthesis in plants, but potassium salts did. Professor Dixon, of Dublin, mentioned that he had unsuccessfully attempted to detect an emission of electrons in chlorophyll preparations.

The Structure of Molecules.

The discourse on the Structure of Molecules by Dr. Irving Langmuir, of the General Electric Company, Schenectady, and the animated discussion following it in a joint session of Sections B and A formed one of the great events of the meeting. Though Dr. Langmuir has since 1916 been publishing articles on his development of the views of Kossel and G. N. Lewis, some of the considerations he submitted were novel and will certainly lead to further controversy. The problem is practically that of valency. We do not know why the atoms of different elements do not all require the same numbers of other atoms for their saturation in compounds; we try to explain by different arrangements of the atoms in space how it may be that iron, *e.g.*, can have different valencies in the compounds FeO and Fe_2O_3, but the recent advances in our knowledge of crystal structure do not help us to clear up these difficulties. Moreover, we have to distinguish, of course, between valency and affinity.

To discuss the structure of the molecule, we should first agree as to the structure of the atom. According to Dr. Langmuir's first postulate, the atomic nucleus is surrounded by successive layers of 2, 8, 8, 18, 18, 32 electrons, these numbers varying as the squares of 1, 2, 3, 4. The first layer of two electrons is his duplet; the duplet hardly concerns the chemist, because chemical properties depend merely upon the outer electrons. Dr. Langmuir uses the term duplet also for pairs of other electrons which are common to two atoms, as we shall see. The second layer is the octet when complete. Further electrons (more than eight), go into the external layer; the layers or sheaths may thus be complete or incomplete. The tendency now is to complete an octet, either by giving up outer electrons (positive valency, or by taking up more electrons (negative valency). Both these valencies are called electro-valencies, and the sum of the positive and negative valencies of any element is always 8. Atoms may combine with one another by transferring electrons, or by sharing electrons. When fluorine (which has seven electrons, one electron too few), and sodium (which has nine electrons, one too many) combine, the latter electron is transferred over to the fluorine, and holds the two atoms or ions together. If we use a cubical model, that case would be represented by two

* He died in July, 1919, and Dr. Forster delivered the Emil Fischer memorial lecture before the Chemical Society last October.

cubes hooked together at one corner. The compound NaF, should not be written, Dr. Langmuir argued, Na-F, as used to be done, as there is no chemical bond in the ordinary sense; the two atoms are already ionised or dissociated. Such compounds (NaCl, MgO, AlF_3) are insulators, but conduct when in the fused condition.

Atoms may further be coupled (postulate 2) by one or more duplets (pairs of electrons) held in common by the complete sheaths of the atoms. Going back to the cubical model, we may put two cubes together with an edge (one duplet in common) or with a face (sharing two duplets). These common duplets Dr. Langmuir calls the covalencies, corresponding to the bonds of the chemists, and his covalencies are supplementary to the electric valencies. According to his third postulate the residual (total) charge on an atom or a group of atoms in a compound tends to a minimum or zero. That postulate, he remarked, seemed to be in conflict with the first, and as long as we did not understand the forces between the electrons and nucleus, he could not put that postulate more definitely. As we pointed out in our comments on the quantum theory, Dr. Langmuir inclines to regard the atomic forces as electrostatic. If such forces were acting alone, however, the atom should collapse. He therefore accepts also some repulsive force, electrodynamic or centrifugal; but the electrons of his atoms are normally stationary, not in rotation. Confirmation of his views he finds in various directions. The Bohr atom, he pointed out, only accounted for radiation phenomena. On his views one could understand compounds like lithium hydride, in which (as Nernst and Moers recently proved) hydrogen appeared as an electronegative constituent. Compounds like CO_2 and N_2O, having the same number and arrangement of electrons, should have the same physical properties, and they had, indeed, except that NO_2 melted at -102 deg. C. and CO_2 at -56 deg. Many predicted isomorphisms had been found, whilst other supposed isomorphisms, not explicable on his views, had been disproved.

During the discussion Professor A. Smithells supported Dr. Langmuir with the aid of models. Professor W. L. Bragg objected that in KCl, X-ray examination showed, one K had the same relations to the six Cl around it, which would not accord with the one transferred electron. In $CaCO_3$ the same examination indicated atomic groups of Ca and of CO_3. In the latter the atoms were very close together, and those relative distances were again not in accordance with Dr. Langmuir's views. The scattering of X-rays suggested a crowding up of all the electrons, not any octet arrangements; Professor Bragg did not say whether he considered the nucleus in these calculations. Professor J. R. Partington, discussing the energy of gaseous molecules and molecular heat, pointed out that dynamic forces were required, as in Bohr's theory, and that static forces were not sufficient. Professor Svante Arrhenius, of Stockholm—one of the fathers of the electrolytic dissociation theory, to whom Dr. Forster (in the chair) had referred as unemployed, since Dr. Langmuir did not require special dissociation—remarked that while the views expressed went back to Faraday and Helmholtz, difficulties would come up as the theory developed.

Professor A. O. Rankine, on the other hand, supported Dr. Langmuir. If we removed the outer electron from rubidium, we should get krypton, and, similarly, we should pass from ammonium to methane. Now, the salts of rubidium and of ammonium had the same molecular volumes (Tutton), and an atom of krypton should hence have the same volume as a molecule of methane; from the viscosity data Dr. Rankine had indeed deduced the same molecular diameters, 3·10 and $3{\cdot}13 \times 10^{-8}$ cm. Dr. E. K. Rideal referred to some difficulties of the octet theory, the structure of the nitrogen molecule—one of Dr. Langmuir's exceptional cases—the formation of so-called cis- and trans-compounds of ethylene and the apparent gradual transition from a polar, ionised compound to a non-ionised compound. As regards the static forces, he suggested that the inverse-square law was found to hold even for sub-atomic distances, because the atoms were static except during actual absorption or emission of energy; they acted as magnetic dipoles, orienting themselves during the passage of charged particles, and the movements were probably oscillatory and not rotatory.

Dr. S. H. C. Briggs, of Sheffield, said that Dr. Langmuir brought the several kinds of valencies, with which the chemist was now confronted, more in harmony with Werner's views on affinity and indicated how Langmuir's kernel—which is not the atomic nucleus, but comprises the nucleus together with the completed sheath—could be introduced into chemical formulæ. Dr. Langmuir having briefly replied to his critics, Sir Oliver Lodge, proposing a vote of thanks, said he was glad that Dr. Langmuir kept an open mind as to static and dynamic forces. Dr. Langmuir, we should add, had stated that he had only recently seen his way clear to reduce the number of his postulates to three, and we are afraid that some of the relative simplicity of his valency equations will go, temporarily at least, when mathematicians examine more fully into the force problem.

Surface Tension Measurements at Extreme Temperatures.

The method which Professor F. M. Jaeger, of Groningen, Netherlands, uses in his determination of surface tension and other properties of inorganic and organic compounds at temperatures ranging from -80 deg. C. up to $+1{,}600$ deg. C., was mentioned by us last year in connection with the Cardiff meeting. He determines the bursting pressure in the liquid substance of a hemispherical bubble of pure nitrogen, formed at the end of a capillary of pure platinum, 0·5 mm. in diameter, the edge of which is kept as sharp as a razor, lest the bubble should spread out into a mushroom of uncertain volume. The capillary is connected with the gauge by spiral tubes which take up distortions, and the gauge is filled with normal octane and mercury. The experiments are made within the 2 or 3 cm. really at constant temperature in a vertical electric furnace; the platinum must be free of iridium, the vapours of which would contaminate the thermocouples of platinum and platinum-rhodium. In the density and electric conductivity experiments the container is a hemisphere, 35 mm. in diameter, of platinum, this cup and an inner concentric hemisphere of 10 mm. diameter forming the electrodes. A float is also used in density measurements. The temperature range applicable is limited by the stability of the substances under test; the surface tension data are said to be reliable within half a per cent.

Dealing with benzene derivatives, Dr. Jaeger found that the free surface energy of closely-related compounds had practically a constant temperature coefficient. When fluorine, chlorine, &c., were substituted for hydrogen, the surface energy increased with the atomic weight of the halogen; isomeric (ortho, meta and para) compounds did not differ much. In the compounds of the halogens with phosphorus, arsenic and antimony, the surface energy also increased as the atomic weight of the halogen increased, *e.g.*, when bromine replaced chlorine; all those compounds so far mentioned have relatively low boiling-points and are poor electric conductors. In the compounds of the halogens with the alkali metals, which are hardly volatile and are good conductors when fused, the opposite rule held; the chlorine compound had a higher surface energy than the bromine and the iodine compound. These fused salts were heteropolar compounds, probably highly dissociated, so that the properties would depend upon both the constituents, *e.g.*, the chlorine and the potassium. The interesting point is that in all the 200 organic compounds and the 50 inorganic compounds examined, both the surface energy and the electric conductivity changed regularly with the temperature. That would indicate that the fused salts cannot be associated liquids (in which the molecules associate to complex groups); but this conclusion, Professor Jaeger remarked, had recently been questioned by R. Lorenz (Frankfurt). The method was only suitable for liquids which wetted the tube, and was hence not applicable to metals.

Surface Tension in the Solidification of Metals.

In a communication bearing this title, Prof. Cecil H. Desch, D.Sc., submitted considerations based upon a comparison of the forms of the grains in solidified metals with those of foam cells. According to Quincke, Dr. Desch stated, substances immediately before solidification separated into two immiscible liquids forming a foam, the liquid present in smaller proportion arranging itself in the cell walls whilst the second main constituent crystallised in the cell, not from outside inwards, but from nuclei in the cell. The crystal grains should then, in their form, resemble soap-bubble cells, though the crystal growth would distort the original cells. Studying foam cells of various soap and glycerine preparations in glass troughs, Dr. Desch did not confirm Kelvin's calculations as to the probable shapes of the cells, but found that pentagonal faces were much more frequent than six-sided and four-sided faces; and this agreed with his examination of the grains of β-brass in a marine propeller and of other alloys. The brasses contained aluminium and broke up into grains when immersed in mercury. If the crystal grain grew simply from the centres their arrangement should conform to the rules of close packing which might be either cubical or hexagonal. In either case the faces should be four-sided, rhombic with cubical packing, trapezoidal with hexagonal packing. If surface tension intervened, the faces should be pentagonal or approximate six-sided and four-sided figures, and that was found to be the case. Thus two forces might be distinguished, a crystallising force and surface tension; with small masses and large surface development, the surface tension might predominate.

The Surface of Liquid Steel.

A few years ago Mr. Cosmo Johns, of Sheffield, suggested that the surface of liquid steel remained optically clean because the escaping vapours of iron kept the air off until the temperature approached the freezing-point of iron, and the vapour tension of the iron was sufficiently lowered; then an oxide film began to form. The suggestion found little support at the time; but in a paper on "The Surface of Liquid Steel," read at Edinburgh, Mr. Johns gave experimental evidence which should induce his critics to change their standpoint. In this interesting paper, which we hope to publish later, he explained that, when a stream of steel was poured, the surface ejected a shower of sparks of apparently globular particles exploding with brilliant flashes; these particles consisted mainly of iron oxides. In addition to these particles, however, condensed fumes could be collected by the aid of magnets, and analyses of such fume particles showed that they were not sprayed metal. If they were, they should have practically the composition of the steel; but the fume particles contained less tungsten than the original steel and more nickel and particularly more manganese, and they probably represented therefore condensed vapours from the steel in the oxidised condition.

We may mention here that a demonstration was made by Professor G. Barger, F.R.S., of Edinburgh, of Micro-Analysis of compounds containing Carbon, Hydrogen and Nitrogen.

The Modern Dyestuff Industry.

In reviewing the "Modern Dyestuff Industry," Professor E. H. Fierz, of Zürich (who, as Dr. Forster remarked in introducing him, had lately spent five years in this country) first dealt with economical features, pointing out that the direct scope of the industry was frequently over-estimated. In 1913 the world's output of dyes had been valued at 20,000,000*l.*, whilst the cotton produced was valued at 120,000,000*l.*, wool at 240,000,000*l.*, cereals at 500,000,000*l.*, pig-iron at 250,000,000*l.*, and rubber at 60,000,000*l.*

In those days Germany controlled 95 per cent. of the dye trade, and as the capital invested was only 10,000,000*l.*, the annual products had twice the value of the capital. To-day that position was reversed; at least 40,000,000*l.* were invested altogether in the dye industry, while the products had not increased. If in 1913 the profits had averaged 16 per cent., only 4 per cent. would be realisable now, and new fields of activity would have to be opened up. Success in the dye industry depended in the first instance upon the quality, purity and uniformity of the materials and products, in the second instance upon continuous progress.

Professor Fierz illustrated the first condition and the need of judicious control by many examples; as regards the latter he remarked that, unless new and better dyes were produced, dye works would drop out of existence and no protective measures, however vigorous, could save them. Although recent advances had not equalled those of the end of the last century, considerable progress had been made. Some old products had been replaced by cheaper and better stuffs. Indigo, still impregnable in many respects, was meeting with strong competition from new vat-dyes and polyazo-colours; alizarine was threatened by fast reds and naphthol A.S. compounds. The search for faster dyes had brought superior substitutes for the old benzidene azo-dyes, and the whole industry of worsted goods was being revolutionised by new inventions.

But all the colour developments, by novel reactions, which Professor Fierz traced out on the blackboard, could not mask the fact of large overproduction. Since 1900 already dye works had been searching for new outlets; that tendency had much increased during the war, and dyes were no longer the only chief products of dye works. Many intermediates and by-products could easily be transformed into valuable drugs, photographic chemicals, tanning materials, and colloidal insulators like bakelite; acetyl cellulose and viscose came from dye works; the synthetic dye of typewriter ribbons had been converted into potent drugs free of the arsenic which had appeared indispensable, and not a few new products had higher values than dyestuffs. Such tendencies should be encouraged by amalgamation and co-operation under scientific management, undisturbed by financial manœuvres. In proposing a well-deserved vote of thanks to Professor Fierz, Professor G. T. Morgan, F.R.S., remarked that well-conducted dyeworks were a real university.

Fuel Economy.

The fourth report of the Committee on Fuel Economy (chairman, Professor W. A. Bone; secretary, Mr. Robert Mond) draws attention to the Gas Committees of the Board of Trade and recommends the limitation of the percentages of both the inerts and the carbon monoxide permissible in gas; three members of the committee, Messrs. E. V. Evans, D. H. Helps and James Yates, dissent from this recommendation. The reports of the Board of Trade Committees have meanwhile been published, and we have dealt with these matters. The report further draws attention to the coal situation and to Mr. Hugh Bramwell's paper on the "Economics of the South Wales Coalfield," to the Committee of the Federation of British Industries which is to assist manufacturers in economising fuel, and to the Smoke Abatement Exhibition to be held in London in March and April, 1922.

Atmospheric Pollution.

The two communications on this subject, one by Dr. J. S. Owens, of London, on "Suspended Impurities in City Air," and the other by Mr. William Thomson, F.R.S.E., F.I.C., of the Royal Institution, Manchester, on "The Pollution of the Air of Manchester and Salford," are printed on pages 554 and 555 of this issue. Both these investigators draw the polluted air through filter paper and estimate the amount of sooty particles from the blackness of the circular or square spot produced. Dr. Owens did not describe this part of his apparatus, but we have noticed it on other occasions. He said that the remarkable clearness of the atmosphere of the past summer, generally ascribed to the coal dispute, might also have been due to the exceptional atmospheric conditions; yet sunshine recorders, recording as a rule differently in smoky and in clear parts of the same town, had given almost the same curves during the dispute period, and the impurity had certainly increased afterwards. Dr. Owens had found the air of Edinburgh more impure than that of London. This statement rather surprised Mr. Thomson in view of the prevalence of wind at Edinburgh—it was blowing hard during the meeting—but syatematic observations were required. The discussion of the papers followed familiar lines.

The Evening Discourses. Cantilever Bridges. Oceanography.

The first of two discourses, delivered by Professor C. E. Inglis, of Cambridge, on "Cantilever Bridge Construction," was undoubtedly one of the best ever given before the Association. Professor Inglis compared the Forth and the Quebec bridges in order to illustrate the evolution of the cantilever bridge during the past thirty years. Adequately to deal with the discourse we should have to reproduce many pages of illustrations which we published when the bridges were built and when disaster twice overtook the Quebec Bridge. Both bridges were masterpieces, the lecturer remarked; the Forth bridge would always remain a monument of engineering skill, though economic conditions would prevent its repetition. If the Forth Bridge were made by hand, the Quebec Bridge was machine made, the members being transported to the site as finished in the machine shops; the cellular compression members of the one had been replaced by the lattice girders in the other, and eye-bars had been adopted for the tension members on the St. Lawrence instead of the riveted members on the Firth of Forth. Professor Inglis preferred the eye-bars; other changes in structural features he rather regarded as concessions to altered workshop practice. In his comments upon the Quebec disasters he agreed, we think, with what we said at the time.

The second discourse was given by Professor W. A. Herdman, F.R.S., of Liverpool, on "Edinburgh and Oceanography." Professor Herdman, last year's President of the Association, had in his address at Cardiff advocated a new Challenger expedition, and that suggestion had found warm support in wide circles. Yet when resigning the chair in the inaugural meeting at Edinburgh, Professor Herdman had announced that after consulting various specialists the council had reluctantly arrived at the decision that the present time was unfavourable for pressing the scheme of a world-wide exploration of the seas upon the Government. The project was therefore in abeyance, and meanwhile a memorandum on the need of such an expedition had been communicated to the Cabinet Secretariat of the Government. In his discourse, Professor Herdman eulogised Edinburgh as the birthplace and home of modern oceanography, referring especially to the work of Edward Forbes—a native of the Isle of Man—John Goodsir, Wyville Thomson and John Murray.

Concluding Remarks.

Further comments upon the transactions of the British Association must be left to special occasions.

The president, Sir Edward Thorpe, recovered sufficiently from his severe indisposition during the course of the week to convince himself of the signal success of the meeting, and to give expression to the general satisfaction and to the gratitude of all the members for the reception accorded to them. Members had indeed reason to be thankful for the arrangements made by the City of Edinburgh, by the Lord Provost, the Right Hon. Thomas Hutchison; the honorary treasurer, Mr. Thomas B. Whitson; and the local secretaries, Mr. Andrew Grierson, the Town Clerk, Professor J. A. Ashworth, F.R.S., and Mr. W. T. Gordon. The last-mentioned, a London geologist, had taken charge of the Hospitality Committee; without his aid and that of his assistants, Miss Turcan and others, many a member might have found himself stranded. The attendance figure, 2,768, has only eight times been exceeded, and only three times by something like a substantial figure.

The attractions of Edinburgh were strong, of course, and the full week's meeting made it worth while once more for some old members, who had dropped off, to take the long journey in spite of the high fares. Much of the scientific success of the meeting has been ascribed to the increased prominence given to general discussions. The tendency is praiseworthy and was widely approved; but it brings up a relativity, time-space problem. The various lecture rooms, though mostly spacious, were more or less crowded by the ordinary meetings. In the joint discussions the crowding became dangerous; all passages and gangways were blocked, and it took many minutes to fill and to clear the rooms again. The point deserves consideration in view of the movement in favour of reducing the number of sections. In some respects it would certainly be an advantage if the 13 sections, to which the Conference of Delegates is to be added, all now deliberating separately, could be reduced to, say, the eight sections of the Edinburgh meeting of 1892. Each section requires its own rooms and staff, it must be remembered. Proposals to that effect were made. But when it came to fixing which sections might go, protests were general. Some members thought, for instance, that botany might re-unite with zoology into biology; but the botanists themselves were positive that they were thriving because they were standing on their own feet. Nothing was done therefore.

The annual grants for research, on average about 1,100*l.* so far, were cut down to about 400*l.*, and allotted in small sums; the further big sums, 100*l.* for seismology, 200*l.* for marine biology, 100*l.* for an experimenter's table in the Naples aquarium, and 40*l.* for the Annual Tables of Constants, came from the Caird Fund, which is independently administered. Next year the British Association is to assemble at Hull on September 5. The 1923 meeting will be held in Liverpool; in 1924 the Association may visit Canada again, for the fourth time, and Toronto for the second time; but that is not yet settled.

THE HERLANDSFOSSEN HYDRO-ELECTRIC PLANT.

(*Concluded from page* 498.)

The power-station, of which we gave an outside view on page 497 *ante*, is built for four units each of 3,500-h.p., working under a net head of 128 m. (420 ft.), and running at 600 r.p.m. These units are now all installed and in operation. Various illustrations of the installation are given in Figs. 13 to 19, pages 532 and 533. Of these, Fig. 13 gives a longitudinal section through the house, showing the four turbines with their respective branch pipes and main shut-off valves, as seen from the generator side, the corresponding plan being shown in Fig. 14. Each of the two 1,400 mm. (55-in.) diameter pipes supplies two turbines. From the outlet of the pipe-line tunnel, the pipes turn through rather less than 90 deg. in a horizontal bend of large radius, and run the length of the power-house. The pipe supplying the two turbines nearest to the tunnel runs under the power-house floor directly below the turbine inlets and the supply pipes turn upwards in a vertical plane to the turbine shut-off valves. The second pipe is laid parallel to the former, past the first two units, and is branched to units No. 3 and No. 4 (Fig. 14). By this arrangement the power-station is protected from pipe-bursts in the tunnel; and bends of small radius which tend to reduce the overall efficiency of the plant are avoided. A cross-section of the power-house is given in Fig. 15, while Fig. 19, page 533, is a general view taken inside the building.

In front of the inlet to each turbine is an hydraulically-operated balanced main shut-off valve of the Johnson-Boving ring type. In order to be able to dismantle and erect this valve, a wedge-shaped section with indiarubber packing is interposed between the embedded casing of the turbine and the pipe line (Fig. 13). This packing is inserted from the inside through a manhole situated on the top of the movable section. By this means this section may easily be removed, and the ring valve made accessible for inspection and repairs, a tight joint being afterwards obtained with very little difficulty. The valve housing is of cast-steel, and its operating cylinder of cast-iron. The working faces of the cylinder and housing are faced with bronze, and the sliding portion is fitted with cup-leather packing. The opening and closing of the valve are effected by a controlling valve placed on a bracket above the floor and arranged for hand operation, but, in addition, closing can also be effected by means of a relay operated by a switch situated in the pulley on the turbine shaft which drives the governor. At a certain adjustable degree of overspeed this switch energises the relay which releases a spiral spring which, in turn, moves the regulating valve to the closing position, thus shutting down the unit. In case of failure of the belt drive to the governor, or of wedging of the turbine guide vanes in the open position, tending to cause the turbine to run away, the ring valve will

THE HERLANDSFOSSEN HYDRO-ELECTRIC PLANT.

Fig. 13.

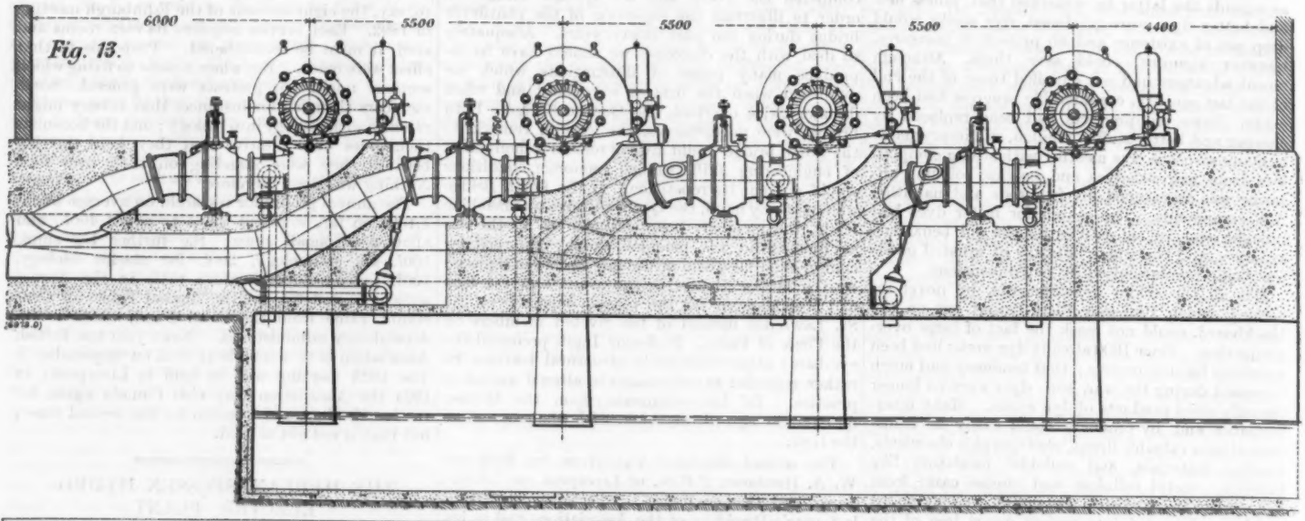


Fig. 14.

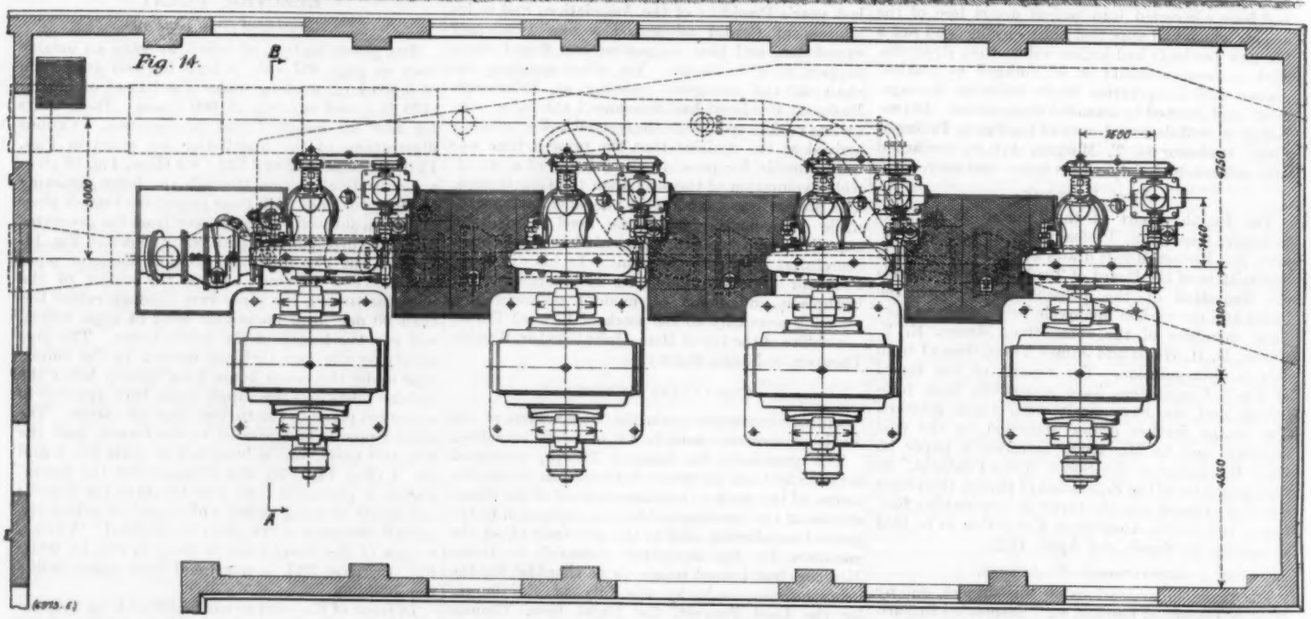


Fig. 15. SECTION A.B.

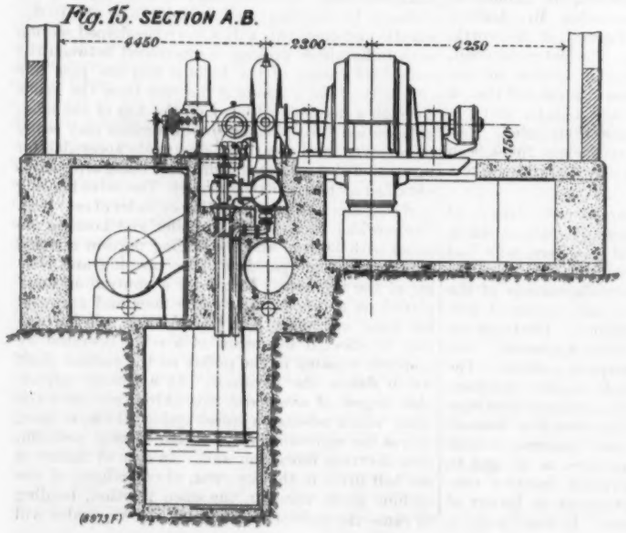
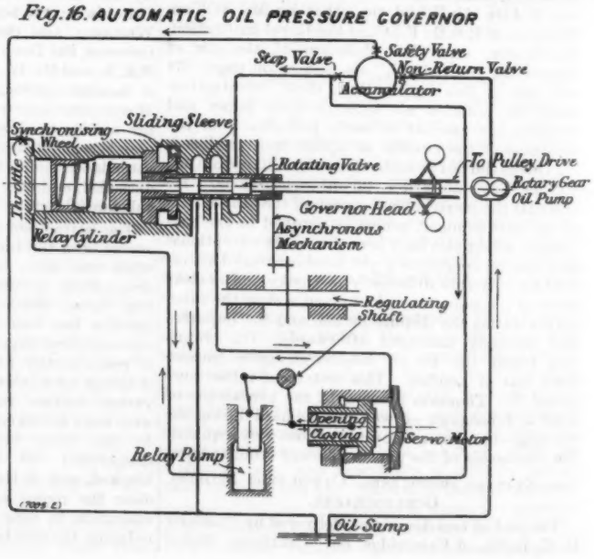


Fig. 16. AUTOMATIC OIL PRESSURE GOVERNOR



THE HERLANDSFOSSEN HYDRO-ELECTRIC PLANT.

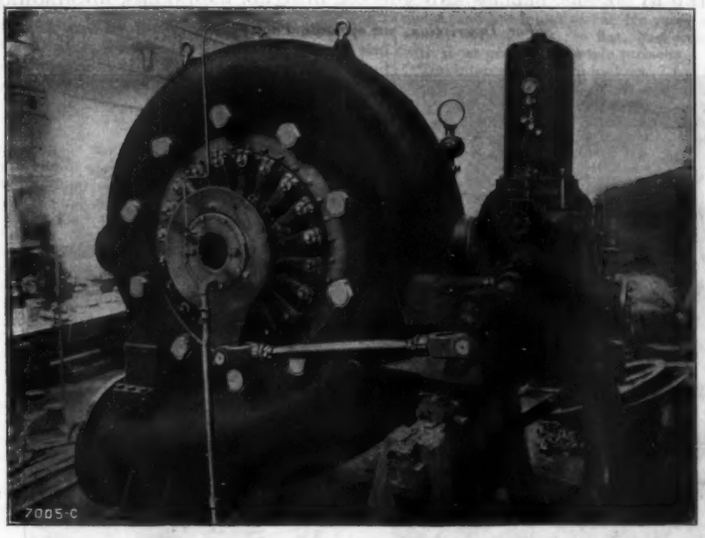


Fig. 17. Turbine, showing Control of Distributor.

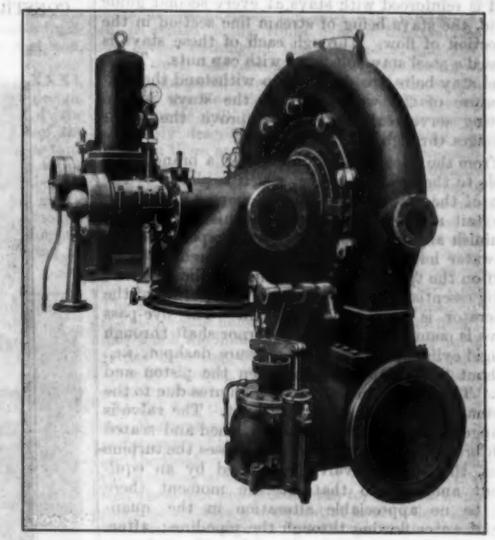


Fig. 18. Turbine, showing Discharge Side and By-Pass Valve.

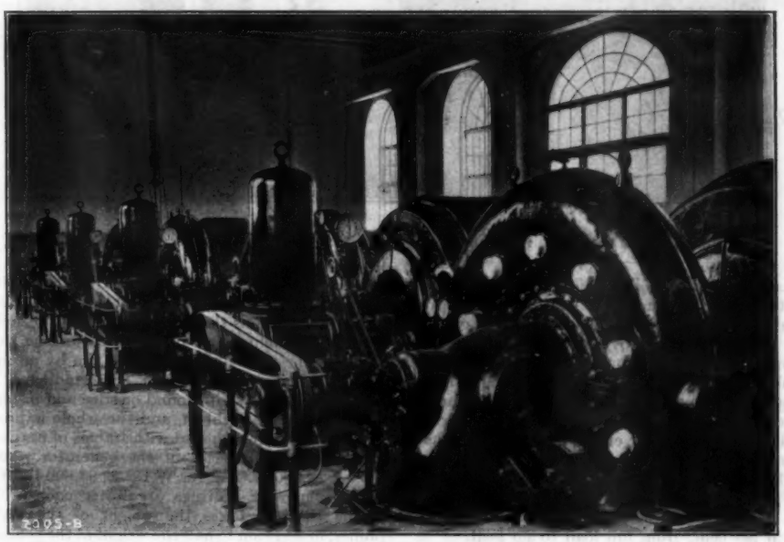


Fig. 19. View of Interior of Power House.

thus be automatically closed and the unit put out of operation.

To vary the closing speed of the ring valve a throttle is introduced into the pressure pipe of the operating servomotor, the setting of which may be adjusted to suit the local conditions in order to prevent a dangerous rise of pressure in the pipe line during the closing of the valve. The valve is also provided with a bye-pass for filling the turbine prior to opening the main valve.

The turbines, of which we give views in Figs. 17 and Fig. 18, above, are of the Francis or reaction type, mounted in spiral casings with horizontal shafts arranged for direct connection to the alternators. To obtain the shortest possible unit, and thus reduce the power-house dimensions as much as possible, the necessary flywheel effect is provided in the alternator and the turbine runner is arranged to overhang on the generator shaft. The weight of the runner is taken by the generator bearing while the unbalanced hydraulic thrust of the runner is taken by a thrust bearing fixed on the suction elbow. The shaft passing to the thrust bearing is connected to the generator shaft by a flange. By this arrangement the overall length of the turbine is made very short, and the unit very compact, as will be seen from Fig. 15.

The turbine runner is of cast-steel with plate steel buckets of 12 mm. ($\frac{1}{2}$ in.) thickness, cast into the rim and hub. To provide more efficient hydraulic conditions, the buckets are made thinner at the inlet and outlet edges. The buckets are forged on a cast-iron die or anvil, and are then ground smooth, after which they are assembled in the wheel mould for casting. By this means buckets are obtained of perfectly homogeneous material, free from blow holes, and having smooth surfaces. In addition, correctly-dimensioned water passages between the buckets are ensured. This method of construction, moreover, produces a runner more resistent to corrosion and erosion than is general with cored-water passages.

The runner is fixed to the extension of the generator shaft by means of a key secured against movement. On account of the very low specific speed of the plant, $n_s = 82{\cdot}5$ (18·6 in British units), the runner has a smaller diameter at the outlet than at the inlet. The hydraulic axial thrust of the runner is balanced as far as possible by the provision of spaces between the runner and the cover plates of the guide mechanism. These spaces are fitted with forged mild steel rings, both on the runner itself and fixed to the casing, capable of being renewed in case of wear, or erosion due to sand in the water. Water leaking through the space between the runner hub and the cover plates is drained away through holes cored in the hub.

The distributor is provided with cast-steel vanes with pivots cast on. These pivots turn in grease-lubricated bronze bushes in the cover and base ring and extend through the cover on the generator side, being provided with stuffing-boxes fitted with double cup-leather packing. Immediately outside the stuffing-boxes are, fixed to the pivots, cast-steel arms, which are connected by bronze bushed mild-steel links with the regulating ring. This ring turns on a grooved seating on the cover plate, and is moved by the governor by means of a steel lever. The seating of the regulating ring and all pivots of the guide vane mechanism are lubricated by means of Stauffer grease cups. The whole of the regulating mechanism is exposed to view and can be greased and kept in order while the turbine is running. The distributor may be dismantled for inspection and the renewal of the vanes by removing the divided cover plate on the discharge side. The whole of the distributor as well as the runner may be dismantled from the discharge side after removing the elbow, without disturbing the generator or generator shaft.

The suction elbow is of cast-iron and rests on a cast-iron foundation ring; the draught tube is of plate steel. The unbalanced hydraulic thrust of the runner is transmitted through a steel collar on the shaft to a bracket thrust bearing on the suction elbow. The collar presses against a seating ring, lined with white metal, and adjustable in an axial direction by means of a wedge-shaped ring provided with set-screws. This bearing is used only to take the unbalanced hydraulic thrust while the load on the turbine is varying; under the regular working load the thrust is balanced by means of the water spaces mentioned above. The thrust bearing can be adjusted to compensate for wear of the lining rings in the balancing spaces. It is self-oiling, and is fitted with water cooling for the oil and for the portion of the shaft within the bearing. Labyrinth stuffing-boxes are provided for the generator shaft in the distributor cover and the suction elbow. These are of the centrifugal type and do not require any packing. They do not

wear the shaft or produce heating, and need no attention.

The spiral casing is of cast iron; cast in one piece, and is reinforced with stays at every second guide vane, the stays being of stream line section in the direction of flow. Through each of these stays is passed a steel stay bolt fitted with cap nuts. These steel stay-bolts are designed to withstand the full pressure of the water, so that the stays in the casting serve really only to improve the water passages through the distributor.

From the inlet to the spiral casing, a branch pipe leads to the bye-pass valve, which is placed at the side of the draught tube and discharges direct into the tail race. The function of this valve is to diminish any rise of pressure in the pipe, lines due to water hammer caused by sudden reduction of load on the turbines, quick closing by the governor being essential in this case, as the momentum of the generator is comparatively small. The bye-pass valve is connected with the governor shaft through a rigid cylinder acting in a pressure dashpot, *i.e.*, without the usual spring between the piston and rod. This arrangement prevents failures due to the accumulation of air in the dashpot. The valve is arranged as a balanced ring valve, lined and seated with bronze. When the governor closes the turbine gates, the bye-pass valve is opened by an equivalent amount, so that at the moment there will be no appreciable alteration in the quantity of water flowing through the pipe-line; afterwards the dashpot slowly closes the valve independently of the governor, by means of a small water pressure servomoter. The speed of closing is controlled by a throttle in the oil pipe of the dashpot, and is adjusted so that no appreciable water hammer occurs.

An automatic oil pressure governor, the standard type of the Myrens Verksted, is provided to control the speed of the turbine. This is illustrated diagrammatically in Fig. 16, page 532. This governor is fitted with an accumulator; the oil pump for this and the governor head are on the same shaft, and the regulating valve rotates with the governor head. The whole is assembled in a casing which embodies an oil sump. The servomotor cylinder is placed horizontally at the base of the governor frame and is integral with it. It is provided with a differential piston which is connected to the regulating shaft by an arm. The regulating shaft is situated above the oil level. The oil pump is of the rotary gear type, and operates at a maximum working pressure of 15 atmospheres. It is belt-driven from the turbine shaft by two separate belts, each capable of carrying the load.

The oil used is drawn from the sump and delivered by the pump, through a non-return valve, into the accumulator situated above. The pump is fitted with an air suction valve to permit sufficient air being pumped into the accumulator. The latter is provided with a spring-loaded safety-valve, which may be adjusted according to the work to be done on the turbine gates. The governor head, is automatically lubricated, and is situated inside the casing above the regulating shaft, and fixed on an extension of the pump shaft. The governor valve rotates inside a sliding sleeve, the position of which is controlled by the fly-weights. It is attached to the regulating valve which rotates directly with it. By this arrangement, wear of the governor sleeve is avoided, and the resulting play and consequent hunting of the unit is prevented. Breakdown caused by seizing of the regulating valve due to small particles of dust, &c., in the oil, is also avoided by this means.

The sleeve fitting round the regulating valve is provided for starting-up and for adjusting the speed for running units in parallel, the sleeve being capable of movement in an axial direction, as already stated. This movement is secured by means of a small wheel operated by hand or by a small electric motor with remote control from the switchboard. The rotating valve is prolonged beyond this sleeve into a relay cylinder, where it is connected to a relay piston by a helical steel spring. This relay provides an automatic return to normal speed for any load. It is connected by an oil pipe to a cylinder whose piston is connected with the regulating arm by an adjustable link motion. This link motion adjustment controls the rapidity of return to normal speed, *i.e.*, the rapidity of regulation. The governor may also be set to provide for a range of speed between full load and no load conditions, if such should be required for parallel running. This is effected by an arm on the sleeve enclosing the valve connected when desired with another arm fixed to the servomotor crank, in such a way that a given position of the turbine gates always corresponds with a given position of the regulating valve and governor head. Thus for synchronous regulation the speed may be arranged to rise or fall from 2 to 5 per cent. from full load to no load.

To prevent the oil from heating there is provided in the oil sump a copper cooling-coil through which a current of water passes. The time taken by the governor in opening and closing the gates can be adjusted within wide limits; and in case of breakdown or insufficient attention, to prevent too rapid action, such as would endanger the turbine or pipe line, the pressure pipe is fitted with a throttle which keeps the speed of the operation within safe limits. Owing to the provision of the bye-pass valve, and to the fact that sudden increases of load are as a rule not so large as sudden decreases, the governor may be adjusted so that the closing time is much shorter than that taken for opening. The turbine may be controlled by hand independently of the governor, the gear for this being thrown into or out of operation, as required.

The alternators are self-ventilating and totally enclosed. They are each designed to give 3,200 k.v.a. at a power factor of 0·75 at a normal voltage of 10,500 at 600 r.p.m. and 50 cycles. The stator core is made in two parts, and may be removed from the frame for rapid renewal of portions of the winding. The coils are former-wound and are practically free from the danger of short circuiting, the winding is designed on the usual Oerlikon method. The rotor is constructed to the Oerlikon design, which possesses a very high mechanical factor of safety, as the wheel rim consists of welded steel rings machined all over and shrunk on to the spider. The poles are fixed to the rim by means of plates and dovetail wedges. The winding of the poles is of copper strip wound on edge and insulated with impregnated ribbon, and the whole is pressed together and strengthened with frames of cast-steel. The moment of inertia of the generator rotor is $GD^2 = 16{,}000$ K.G.M.^{2} or W.R.$^2 = 94{,}800$ lb.-ft.^{2}.

The generator bearings are water cooled. One of the bearings takes the weight of the turbine runner, in addition to half the weight of the generator rotor. At the end of the generator shaft, away from the turbine, is mounted a direct connected compound-wound exciter of 35 kw. at 115 volts; 10 kw. is taken from the exciter units for emergency lighting.

The power plant was completed with all four units in position in the autumn of 1920, and the acceptance tests *in situ* were carried out in February, 1921. The test efficiency exceeded the guaranteed figures by several per cent., and the whole of the machinery has been running satisfactorily since that date. The turbines were pressure tested in the manufacturers' shops to 250 m. (820 ft.) water-pressure, *i.e.*, about 100 per cent. above the static pressure.

The general design of the plant was drawn up by Over-Ingenior H. Schjerven, who also supervised the construction. The electrical consultants were Messrs. Nissen and von Krogh, of Christiania. The turbines and accessories, together with the automatic flap sluice and other sluices, the hoisting gear, and the whole of the intake machinery were by Messrs. J. and A. Jensen and Dahl, of the Myrens Verksted, Christiania.

This firm is now working in conjunction with Messrs. Sir W. G. Armstrong, Whitworth and Co., Limited, 8, Great George-street, Westminster, S.W.1,

6,500 CUBIC FEET AIR COMPRESSOR.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see opposite Page.*)

Fig. 1. Interior of Compressor House, New Modderfontein Gold Mine.

who are now taking up the construction of all sizes of turbines of the Francis and Pelton Wheel type to the designs of Messrs. Jensen and Dahl. The pipe lines were supplied by the Fredrikstad Mekaniske Verksted, Fredrikstad, through Messrs. Jensen and Dahl, and by the Verkstaden, Kristinehamm. The generators were by the Oerlikon Company and the switchgear by the Per Kure, Norsk Motor and Dynamo Fabrik, Kristiania.

THE "BELLISS" AIR COMPRESSOR.

MESSRS. BELLISS AND MORCOM have been makers of air compressors for the past thirty years, but in its present form the Belliss compressor dates from 1907, and is a development of the well-known high-speed Belliss engine, including the system of forced lubrication originated by the firm in 1890. It is, in fact, the Belliss engine with air cylinders substituted for steam cylinders. This type of compressor has been very successful, and a large number have been supplied to all parts of the world. A considerable proportion of the earlier compressors went to the Rand and to the mining districts of Australia. More recently, during the war, when compressors were wanted for speeding up the shipbuilding industry, a Government commission reported in favour of the Belliss compressor and 50 large compressors—25 of 3,000 cub. ft. and 25 of 1,500 cub. ft. per minute—were ordered for distribution throughout the various shipyards. Since the termination of hostilities the French Government Commission for re-equipping the mines in the Invaded Districts of France, after examining various makes of compressor, French, English and American, reported in favour of the Belliss compressor and 60 machines of 2,000 cub. ft. capacity were ordered, many of which have been delivered.

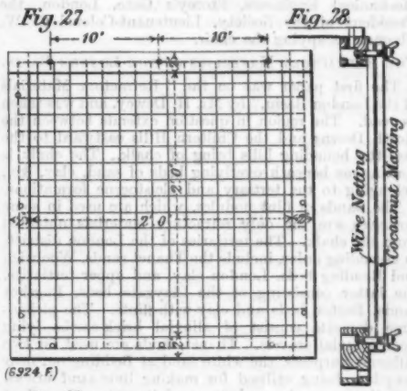
We illustrate on the present and opposite pages, and on Plate XXXI, a motor-driven compressor, having a capacity of 6,500 cub. ft. per minute, of which Messrs. Belliss and Morcom have supplied 9 for the Rand, in addition to two installed in England. Such a machine is capable of supplying air for 65 rock drills. Fig. 1, on page 534, illustrates the compressor house at the New Modderfontein Gold Mine, equipped with four machines of this size and type, while Figs. 2, 3 and 4, Plate XXXI, show the general arrangement of the compressor and motor. It will be seen that the motor, which is of the three-phase induction type, 1,000 h.p., is placed on the concrete foundation independently of the compressor, the only connection being at the coupling, which is of the solid type. This is in accordance with the usual practice for electric generating sets of the same capacity, a combination baseplate being dispensed with. The latter arrangement is sometimes preferred as giving a finish to the set, but a baseplate is comparatively flexible and can be easily sprung in tightening up the holding-down bolts, or even by its own weight, and the alignment must always depend on the rigidity of the concrete. Another noteworthy point is that the motor has a single outer bearing only. Many engineers consider that an induction motor should be complete with its own bearings owing to the small clearance at the rotor, but we are informed that no trouble has been experienced with these machines, or indeed with numerous other air compressing sets with the motors similarly disposed. The advantage of dispensing with the intermediate bearing in the reduction of overall length of the compressing set is obvious. And the arrangement avoids certain troubles which have been found to arise when an intermediate bearing is fitted.

Figs. 5 and 6, Plate XXXI, show the compressor in section. The design is so simple as to hardly stand in need of explanation. The air cylinders are, first stage, 47 in., second stage, 27 in. diam. × 25 in. stroke, and the designed speed of revolution is 166½ per minute. The cylinders are completely enveloped by water jackets, through which the cooling water is circulated in series, first passing through the first stage, then the second stage, and then through the inter-cooler. The pistons are fitted with Rowans patent piston rings, and the piston rods with Messrs. Belliss and Morcom's own standard design of metallic packing. Where the piston rods pass through the top of the crank casing, scraper rings are fitted, these constituting another set of metallic packing, specially designed for preventing oil being carried up by the rods. There is also a distance in excess of the full stroke between these scraper rings and the cylinder packing, preventing any possibility of low flash oil from the crank-chamber being carried up into the air cylinders and there becoming carbonised and clogging the valves or being carried over with the air to cause troubles with the hose and pneumatic tools.

The air valves are thin plate valves of the Rogler-Hoerbiger patent design, but made in Messrs. Belliss' Works. The connecting rods have double-bearing top ends, affording an effective steady to the piston rods conducive to quiet working, besides affording ample bearing surface. The system of forced lubrication is too well-known to need description, but it may be stated that the oil pumps are in duplicate and that provision is made for continuously cooling the oil. The bearings are of cast iron lined with antifriction metal, and are found to run for years without adjustment. The guides are flat, cast-iron on cast-iron, with shoes presenting ample surface.

The Intercooler shown by Figs. 7 to 21, Plate XXXI, is of Messrs. Belliss' patented counter-current design, but specially modified to meet the views of the customers, being so arranged that the whole of the tubes can be lifted out and dropped into a tank provided with a steam coil so that any grease which may have accumulated may be removed by boiling out with a soda solution. The quantity of grease which accumulates is, however, not large in amount, owing to the arrangements above mentioned for preventing oil from the crank chamber from finding its

FIG. 26.



way into the air cylinders and the very small quantity of oil required for the internal lubrication of the air cylinders. The customers report that one pint of oil was found sufficient for the lubrication of the cylinders and bearings of each of these compressors per day of 24 hours continuous running, of which quantity four-fifths was used in the air cylinders. The makers draw attention to the very small quantity of oil which their compressors do require, and instance another compressor of 400 cub. ft. per minute capacity which has been running for years past with only a teaspoonful of oil given once per working day of 10 hours to each cylinder. The average attendant is too prone to flood the cylinders of a compressor with oil, without considering that a well designed and efficient compressor requires only a very slight quantity of oil for internal lubrication. There are only the two piston rings and packings to lubricate, and the cylinder surfaces are kept cool by water jacketing. With thin plate valves of the Rogler-Hoerbiger type there are no sliding surfaces and the less oil these valves have the better. Oil in excess in air compressor cylinders is detrimental as it tends to collect the dirt which comes in with the air, and if it accumulates in the discharge pipes and air receivers may cause an explosion.

The mention of dirt suggests another point which is too often overlooked in connection with air compressors. A steam engine would not be expected to run satisfactorily and without excessive wear and tear if the steam came over heavily charged with impurities, but it is too often taken for granted that this is the natural condition of working a compressor. But experience has shown that the cost of any apparatus for eliminating the dust and grit from the air is repaid many times over (a thousandfold) in the better working of the compressor, and freedom from wear and from tendency to derangement. Fig. 26, annexed, shows the outside of the compressor house at the New Modderfontein Gold Mine equipped with four 65-drill Belliss motor-driven compressors as previously described, with the air straining houses, of which there are two for the four compressors. The four sides of the air strainer houses are fitted with filter frames, the air straining medium consisting of the best cocoanut fibre matting. The area of the matting should be at the rate of 3 sq. in. per cubic foot of free air compressed per minute. Details of one of these frames are shown in Figs. 27 to 29, annexed. It will be noted that they are attached by studs with fly-nuts so as to be easily removable for cleaning. The interior of the air strainer house is connected with the compressor house by a culvert below the floor level, into which the inlet pipes of the compressors dip down. It has been suggested that these strainer houses act more by allowing a quiet place for the dust to settle down in. than by the dust being caught in the straining material, but there is no doubt they are effective, and the Management attribute the extraordinarily good performance of these compressors in everyday operation and the freedom from wear and tear to the excellence of the straining arrangements. A report received states that these four compressors ran for five years, most of this time six days a week and 24 hours a day, and that the number of valve plates broken on the four machines total two, during the whole of this time. Seeing that there are 140 valves, this probably constitutes a record.

The method of air control in these compressors consists of a valve of the equilibrium double-beat type on the inlet, controlled by an air relay so designed that on the air pressure exceeding the intended pressure by 3 per cent. to 5 per cent., the air supply is cut off entirely, the pistons running in vacuo until the demand again causes the pressure to fall. This constitutes the most efficient system of control possible, as the compressor is either running at full load and efficiency, or at dead light load with the pistons in vacuo, indicator cards taken at No Load showing between 28 in. and 29 in. vacuum in the first-stage cylinder. The very small amount of power required for operating a Belliss compressor at No Load is proved by Figs. 22 and 23, Plate XXXI, which show indicator cards taken at full and no loads from a Belliss compressor. It will be noted that the indicated horse-power at no load is less than three-quarters of one per cent. of the full load power, and that the total horse-power required to operate the compressor at no load including the friction of the bearings, piston rings and packings and the resistance of the rarefied air in the cylinders is only 4·22 per cent. of the power at full load. It may be stated that very special precautions were taken to ensure the accuracy of these results, the compressor being operated by a small motor operating at about its full rating when driving the compressor at no load, the motor being brake-tested at the same power. It is not necessary to enlarge upon the method of testing adopted, as it was fully described on page 8 of the issue of ENGINEERING for July 5, 1918.

The following particulars of independent tests of two different examples of the 65-drill standard size of compressor previously illustrated and described will be found of interest.

Two Stage Belliss Motor-Driven Air Compressor, No. 955 at Penallta Colliery.

Summary of observations and results recorded at the test on site by the representatives of The Powell Duffryn Steam Coal Company, July 17, 1919.

(1) *Particulars of Compressor :—*

Air cylinders—	
First stage, diameter	47 in.
Second stage, diameter ...	27 in.
Stroke	25 in.
Output, cubic ft. free air per minute	6500
Air pressure, ... lb. per square inch gauge	75
Designed speed ... ... r.p.m.	166½
Altitude	Approximate Sea Level.

(2) *Observations :—*

Actual speed ... ... r.p.m.	163
Air Pressures—	
First stage intake ...	14·51 lb. per square in. absolute.
Intercooler	27 lb. per sq. in. gauge
P_3 = Second stage discharge	75 lb. per sq. in. gauge
Air temperatures—	
First stage intake	67° F.
First stage discharge	251° F.
Second stage intake	83° F.
Second stage discharge ...	229° F.

Air measuring orifice readings—

T_0 = Mean atmospheric temperature at compressor intake	= 67° F. = 528° F. absolute
T_1 = Mean temperature of air approaching orifice	= 182·3° F. = 643·3° F. absolute
P_0 = Mean atmospheric pressure at compressor intake	= 29·53 in. Hg = 14·51 lb. per square in. absolute
P_1 = Mean pressure of air approaching orifice	= 89·51 lb. per square in. absolute
P_2 = Mean pressure of air leaving orifice	= 84·46 lb. per square in. absolute
where $P_2 = P_1 - h$ and h = 10·28 in. Hg ...	= 5·044 lb. per square in.
A = Area of orifice throat	= 8·91 sq. in.

Electrical log—

Indicating wattmeter mean reading	= 645·0
Frequency, periods per second	= 49·5
Voltage at bus bars	= 2880
Power factor	= 0·79

(3) *Calibrations* :—

Wattmeter constant	= 1·32
C = Co-efficient of discharge of orifice	= 0·995

(4) *Physical constants and assumptions* :—

g = Acceleration due to gravity = 32·2 ft./sec.^{2}

$R = \frac{PV}{T}$ for air in feet/lb.—

Fahrenheit units ... ... = 53·3

Mechanical efficiency of motor = 93 per cent.

(5) *Calculations* :—

Air Output—

lbs. per second $= C A (2g/R)^{\frac{1}{2}} (h P_2/T_1)^{\frac{1}{2}} (1 - h/28P_2)$

$= 0{\cdot}995 \times 8{\cdot}91 (2 \times 32{\cdot}2/53{\cdot}3)^{\frac{1}{2}} (5{\cdot}044 \times 84{\cdot}46/643{\cdot}3)^{\frac{1}{2}} \times (1 - 5{\cdot}044/28 \times 84{\cdot}46) = 7{\cdot}914.$

Weight of 1 cub. ft. air at P_0 and $T_0 = P_0 \times 144/R\,T_0 = 14{\cdot}51 \times 144/53{\cdot}3 \times 528 = 0{\cdot}07424$ lb.

Cub. ft. free air per minute = 7·914 × 60/0·07424 = 6396,

or corrected to specified speed = 6396 × 166·5/163 = 6533 cub. ft. per min.

Isothermal Work.

Foot pounds per lb. of air $= R\,T_0 \log_e (P_2/P_0) = 53{\cdot}3 \times 528 \times \log_e (89{\cdot}51/14{\cdot}51) = 51{,}207.$

Isothermal horse-power = 7·914 × 51,207 × 60/33,000 = 737.

Indicated air horse-power—

Mean of 5 sets of diagrams taken simultaneously with orifice and electrical readings = 993

Electrical input of motor—

Kilowatts = 645 × 1·32 = 851

E.H.P. = 851/0·746 = 1141

Brake horse-power input of compressor = 1141 × 0·93 = 1061.

(6) *Efficiencies*—

Mechanical efficiency of compressor = air I.H.P./B.H.P. = 993 × 100/1061 = 93·5 per cent.

Isothermal efficiency of compression = isothermal H.P./air I.H.P. = 737 × 100/993 = 74·3 per cent.

Isothermal overall efficiency of compression = isothermal H.P./B.H.P. = 737 × 100/1061 = 69·5 per cent.

Isothermal overall efficiency of combined plant = isothermal H.P./E.H.P. = 737 × 100/1141 = 64·6 per cent.

(7) *Sundry observations.*—The starting effort was observed to be approximately 277 kw. or 32·5 per cent. of full load effort for the combination.

With the inlet valve shut and full pressure on the discharge valves the power taken to operate the compressor and motor was 72·5 kw. = 97·3 e.h.p. or 8½ per cent. of the full load power of the combination.

The temperature of the oil in the crank chamber was 105 deg. F. at the end of the trial of 4½ hours.

(8) *Remarks.*—The measurement of the air delivered by the compressor was effected at a rounded approach orifice (see Figs. 24 and 25, Plate XXXI), situated in the main discharge pipe at a distance of about 160 ft. from the compressor. The air was made to pass through the orifice steadily and without pulsation by slightly throttling it at a stop valve at about 50 ft. from the compressor. Without closing this valve sufficiently to cause an observable drop in pressure past it, it was possible to get perfectly steady conditions at the orifice, as indicated by the steadiness of the mercury column used to measure the pressure drop across the orifice.

The formula used to calculate the air delivered was that given in the proceedings of the Institution of Civil Engineers, 1916–17, in the paper entitled "The Commercial Metering of Air, Gas and Steam," by John Lawrence Hodgson, B.Sc.

The orifice used, and the formula used for calculating the air delivered are similar to those in use on the Rand, for the buying and selling of large quantities of compressed air, and the results may be considered as embodying the best possible accuracy under ordinary testing conditions.

A test was conducted on a duplicate motor-driven air compressor at the New Modder circular shaft on the Rand, South Africa, on March 14, 1920, in the presence of representative engineers of the New Modderfontein Gold Mining Company, Limited, The Rand Mines Power Supply Company and the vendors.

Measurements.—The electrical input measurements were taken by a calibrated indicating wattmeter (Westinghouse pattern), specially imported by the suppliers and also by an indicating wattmeter supplied by the Victoria Falls and Transvaal Power Company, Limited.

The air measurements were taken on the standard orifices agreed to between The New Modderfontein Gold Mining Company, Limited and The Rand Mines Power Supply Company, four orifices being used in series and the average being taken.

Results Obtained.

Altitude feet above sea level ...	5,600 ft. approximate.		
Atmospheric pressure at compressor intake	12·275 lb. per square inch absolute.		
Absolute pressure at compressor discharge lb. per square in.	95·19	105·06	113·26
	per cent.	per cent.	per cent.
Isothermal overall efficiency of motor and compressor = *i.e.*, Isothermal horse-power ÷ electrical horse-power.	62·76	62·14	61·05

Graph of results.—If E, the overall efficiency is plotted against the ratio P_2/P_1, of the absolute pressures at discharge and intake, the equation of the best fitting straight line, through the observed points, is found to be

$$E = 71{\cdot}98 - 1{\cdot}177\ P_2/P_1.$$

Comparison of results.—If the Penallta compressor conditions, of intake pressure 14·51 lb. per square inch absolute, and discharge pressure 89·51 lb. per square inch absolute, are substituted in the above equation an overall efficiency of 64·72 per cent. is obtained. This agrees very closely with the 64·6 per cent. actually recorded on the test of that compressor on site already described. The results of the independent tests of these two compressors thus approximate very closely, especially in view of the difference in location, personnel, measuring instruments, &c., being indeed within ½ of 1 per cent. of each other.

THE CERAMIC SOCIETY.

Refractory Materials Section.

The autumn meeting of the Refractory Materials Section of the Ceramic Society was held on October 6 and 7, at the Meeting Hall of the Institution of Mechanical Engineers, Storey's Gate, London, the President of the Society, Lieutenant-Colonel C. W. Thomas occupying the chair.

The Refractory Materials of the London Basin.

The first paper was on the "Refractory Materials of the London Basin," by Mr. H. Dewey, and was taken as read. The region in question extends between the North Downs and the Chiltern Hills eastward to the sea, the bounding hills being of chalk. The chalk is continuous beneath overlying beds of sand, clay, &c., belonging to the tertiary and pleistocene formations.

The bands of flint nodules, which are used in some potteries are the only refractory materials obtained from the chalk. The tertiaries of the London district, in ascending order, include the Thanet sands, Woolwich and Reading beds, London clay, and upper tertiaries, the latter consisting of the Claygate beds, Bagshot sands, Barton beds and clay-with-flints. The pleistocene deposits consist of alluvial brick-earths lying upon alluvial gravels. Thanet sands are used for two different purposes, the white sand at Beddington, near Croydon, being utilised for making lime-sand bricks, and the more clayey bottom of the Thanet sand at Erith serving as an excellent moulding sand for foundries. It is said that its abundance locally determined the site of Woolwich Arsenal. Clays belonging to the Woolwich and Reading beds, the London clay, and the upper tertiaries, are largely employed for making building bricks and tiles. A loamy sand in the Woolwich and Reading beds, but found only at Epsom and Ewell, was formerly worked for moulding sand for goldsmiths, and more recently has been applied to the production of refractory wares for many gas works in London and elsewhere. The London clay, which is the principal tertiary deposit in the London basin, has been worked extensively, not only for making red bricks but also for manufacturing Portland cement. The alluvial brick-earths formerly supplied London with most of its building bricks, and some are still worked at Crayford and Erith.

The Marlow Gas-Fired Tunnel Oven.

Mr. J. H. Marlow read a paper entitled "The Marlow Gas-Fired Tunnel Oven." The three main features are a simple but effective gas producer, a system for preheating the air and superheating gases before combustion takes place, and the exhaust to draw the heat through the centre of the tunnel and not to pull it along the walls. The exhaust, which the author regards as the governing feature, consists of a system of pipes. A temperature of 1,140 deg. C. can be attained within 48 hours from the time of lighting the fire in the producer, and a rise or fall of 100 deg. C. can be effected in 3 hours. For some weeks the same tunnel oven has been used (on different days) for firing glost ware at 1,130 deg. C., earthenware biscuit at 1,180 deg. C., and floor tiles at 1,220 deg. C., at the works of Messrs. Minton, Hollins and Co., Stoke-on-Trent. The air which passes in to keep the bottoms of the carriers cool is caused to part with some of its heat to preheat other air, and is afterwards led to the fan. There is a subsidiary combustion chamber, constructed outside the oven or kiln, in which the temperature is raised to about 900 deg. C., which enables the temperature of the tunnel to be raised quickly by preheating the air before meeting the gases for combustion. For 44 cwt. of coke now used in 24 hours, the weight of fired goods obtained is 276 cwt. A further communication was promised for some future date.

The Combustion of Oil Fuel.

Mr. Percival J. Woolf next read a paper on the "Combustion of Oil Fuel," with special reference to a new type of tunnel kiln. The rising temperature in any combustion process is affected primarily by the heat energy in the material burned, the total quantity of the products of combustion, the dilution of the products of combustion with neutral material, and the confinement of the space of combustion. A pound of carbon yields 14,500 B.Th.U., and a pound of hydrogen yields about 60,000 B.Th.U.; but as carbon requires 2⅔ times its own weight of oxygen for complete combustion, whilst hydrogen requires eight times its weight of oxygen, and in each case the heat energy would be distributed among all the products of combustion. The substitution of air for oxygen, as in ordinary practice, gives correspondingly larger amounts of material, and the temperature of the products would of course be reduced. In a confined space, when expansion cannot take place, increased pressure results, and this is associated with increased temperature.

In practice, it generally happens that a considerable excess of air must be used, and the heating up of the excess air gives a lower temperature. The necessity of using excess air arises from the impossibility of properly mixing gaseous substances like air with solids or liquids, however finely divided they may be. On the other hand gases readily mix with gases, and so the burning of combustible gases with air can be easily controlled, and excess of air is not required for complete combustion. In this lies the advantage of converting solid fuel like coal, or liquid fuel like petroleum and its products, into gaseous form. Fuel oil, so-called, is the residue of petroleum oil, after the removal of lighter products, or naphtha. Ordinarily, it contains about 86 per cent. carbon, 12 per cent. hydrogen, with 2 per cent. sulphur and ash, &c., and its heat value in this country averages about 19,000 B.Th.U. per pound. Fuel oil, though varying only slightly in composition, varies in other respects according to the source and treatment of the crude oil from which it is derived, the weight of a gallon ranging from about 7½ lb. to about 8½ lb., the lighter oils being also the more fluid. Experiments with some fuel oils indicate that very little is vaporised below 200 deg. C., and only a small proportion up to 300 deg. C., but at 400 deg. C. over 95 per cent. is vaporised, and at 450 deg. C. less than 1 per cent. of solid remains.

The earlier methods of burning fuel oil utilised the oil in the form of spray, the oil being ejected under pressure through a fine orifice to meet a strong current of air which broke it up into a spray. This method of spraying has been called "atomising," though even the finest particles of the oil are very dense compared with the molecules of gases. It is found that 25 per cent. or more excess air must be used in atomising. Owing to the imperfect mixing of oil and air, the effect of which is increased by the different velocities with which their respective particles travel, combustion lags.

In very large furnaces the mixed stream will travel several feet before ignition takes place, the part of the furnace next the entrance being inert as regards combustion. In smaller furnaces the stream is checked on striking the opposite walls, and the impact mixes the materials, and the oil is then partly vaporised by contact with a hot surface, and combustion is started. The velocity required to inject the mixture is usually 200 ft. to 500 ft. per second, and the mixture will generally reach the opposite end of a small furnace so quickly that there is not time for complete combustion. Hence it commonly happens that where an outlet from the furnace is available an emerging flame indicates completion of the combustion after the mixture has left the furnace. For better mixing of the fuel and air in the spray type of furnace, combustion is accelerated by admitting an excessive amount of air with the fuel, or by elongation of the furnace to allow more time for combustion. The use of excess of air involves lower temperatures and lower heating effects, and therefore also greater consumption of fuel, besides furnishing an oxidising agent, which is objectionable in metallurgical furnaces. To obviate some of the difficulties associated with the spray method of burning oil, the most common device is the addition of a combustion chamber, separate and more or less distinct from the heating chamber of

the furnace. Combustion is thus started in one section of the furnace, and finished in the other, the heating effect being more uniform in the latter. For the best results, such a combustion chamber should be about one-third the size of the heating chamber. The main advantage of a combustion chamber is for better distribution of heat, but it also gives a somewhat reduced oxidation effect. The disadvantages of a separate combustion chamber are that the heating is effected at a lower temperature than that in the combustion chamber, and that the increased size of the furnace increases the standby losses.

To eliminate the excess air in burning oil, and at the same time obtain perfect combustion within the furnace proper, without increasing the size of the furnace, the vaporisation and mixing of the oil and air before entering the furnace has been accomplished by the Sklovsky U.S. Patent No. 1,229,338. Compressed air is forced through heating chambers which utilise the heat from the outgoing gases, and then through a vaporising chamber. Into this latter chamber fuel oil percolates (not under pressure), through the inlet, and passes through the vaporiser with a stream of heated air. By the time the exit of the vaporiser is reached, the oil is completely vaporised and intimately mixed with air, and the mixture then passes through a tube directly into the combustion chamber of the furnace. In this design the temperature of the air is kept between 300 deg. and 450 deg. C., preferably between 350 deg. and 400 deg. C. The tube connecting the vaporiser and combustion chamber, is so proportioned that the velocity of the mixture through the tube suffices to prevent a recession of the flame from the combustion chamber back into the tube and so into the vaporiser. Consequently the combustion takes place immediately upon entrance into the combustion chamber, and a uniform temperature is maintained in the combustion or heating chamber. The mixture burns with the exact amount of air chemically required, giving higher temperatures within the furnace and therefore more rapid heating. Incidentally, the combustion chamber being uniformly of high temperature is smaller in size, and so has a low radiation surface throughout the exterior. The absence of excess air diminishes the oxidation effect on the material.

The remainder of the paper related to "Oilgas" continuous compensating furnaces or tunnel kilns, which can be worked at temperatures of 500 deg. to 2,000 deg. C. with absolute control of the tunnel temperature. These have been produced quite recently by the General Combustion Company under the Kirk patents. The "Oilgas" compensating furnace is a twin-chamber furnace, in which the material passes through the two chambers in opposite directions. The heating zone is near the centre, a single source of heat supplying both chambers, and the entering cold goods are preheated by the hot goods proceeding towards the exit. The efficiency of this heat transfer is dependent upon the natural convection currents set up in the inert atmosphere of the furnace by the heat radiated from the charge.

The central wall between the two tunnels or chambers is perforated near the top and bottom. Where the convection currents are upwards the hot rising air passes through the upper openings into the adjoining chamber, and a colder charge being encountered there, the air currents are cooled and fall rapidly to the bottom of the chamber, passing through the lower openings back to the hotter charge. Thus gradual preheating and gradual cooling are effected, with an equalisation of heat throughout each carload of charge, prevention of local overheating, and prevention of too rapid local cooling.

The heating zone is heated by the products of combustion from external combustion chambers if more than these are on opposite sides of the kiln and without any intercommunication. The hot gases pass upwards through flues in the side walls, closed to the heating chamber by hollow carborundum tiles, thence across both chambers through transverse flues formed of carborundum tiles to a longitudinal flue, whence the gases escape along the side wall in the direction of the incoming goods. The combination of combustion chambers and cross flues ensures a definite controllable zonal heat distribution. Any desired heating can be provided with certainty. Before the spent gases escape, a final radiation section extracts the last useful degree of heat from them. In this radiation section alloy plates are substituted for carborundum tiles, and "Oilgas" recuperators preheat all the air (up to 1,350 deg. to 1,400 deg. C.) for the combustion system. The charge is never subjected to direct flame action, and the muffle is so perfect that all heating operations, except bright and gray annealing of steel, may be successfully accomplished without the use of containers or saggars.

Practically no heat is lost through the car bottoms owing to the use of effective continuous seals. This is evidenced by temperature tests and by the fact that the lubricating oil on the roller bearings is not burnt. No elaborate system of air cooling is necessary for the bottoms and bearings of the car because no heat is permitted to escape. Concrete evidence of fuel economy includes an actual run where the percentage of fuel (coal equivalent) to charge treated was reduced to 2½ per cent. The use of air locks, at the ends of the furnace to charge and discharge the cars, serves to avoid any longitudinal disturbance of the inert furnace atmosphere. This fact, together with the entire absence of cooling by drawing outside air through the furnace chamber, explains the remarkable freedom from scaling in annealing metals.

The "Oilgas" compensating type of furnace is adaptable for any long continued heating cycle, for bisque and glost firing of china and earthenware, sanitary pottery, &c., firing of building bricks and firebricks, terra-cotta and floor tiles, annealing of sheet steel, punchings, drawn steel wire, steel and iron castings, malleabilising, &c. The time has been brought from eight days down to five for malleable iron, and will probably soon be reduced to four days. In one plant in the United States, annealing sheet steel, a reduction in fuel from 47 gallons to less than 6 gallons of oil per ton annealed has been accomplished, and with a product improved in quality.

Fuel oil can now be purchased for 4*d.* per ton delivered at Manchester. No stacks are necessary on "Oilgas" kilns, but a small pipe to carry off the spent gases is recommended.

ALUMINA, CORUNDUM AND ALUMINA-THERMIC CORUNDUM IN REFRACTORIES.

The last of the morning papers, "Alumina, Corundum, and Especially Alumino-thermic Corundum, as Refractories," by Dr. A. Granger, was taken as read. Pure alumina is very refractory, but its use is restricted because the price is high, the material is flaky and the calcined material shrinks considerably, the contraction increasing with the temperature. A mixture of French china clay and calcined alumina (equal parts) was heated to cone 14, ground, and used as aluminous cement. This cement with a little of the same china clay added was made into crucibles, which were found to be refractory, but the shrinkage was so great that the crucibles often cracked after one heating. The same tendency to cracking was found in crucibles made without any free china clay, and even with pure alumina, so that strongly calcined alumina had to be used.

Very satisfactory crucibles were made from a mixture of Canadian corundum (natural) and china clay, for crucibles heated to cone 26 could be immersed in cold water without becoming cracked. Owing to the high price and uncertain supply of the corundum the investigation was not continued further, especially as complications arose through the granting of German and French patents for the use of natural and artificial corundum in ceramic bodies.

The residue from alumino-thermic operations was available, but Goldschmidt's reaction is not strictly represented by the equation $Fe_2O_3 + 2Al = Al_2O_3 + 2Fe$, for the melted alumina at very high temperatures reacts with ferric oxide, and the original reaction ceases when about 85 per cent. of metal is produced. The corundum thus contains iron aluminate, and similar changes take place with manganese and chromium, though the limit of the reaction varies slightly from the figure mentioned.

Of these alumino-thermic corundums, iron corundum is light brown, manganese corundum is greenish grey, and chromium corundum is ruby pink. This last is not pure, but contains particles of aluminium and chromium. When purified it seemed the most appropriate as a refractory material. The corundum is washed and heated with dilute sulphuric acid until effervescence ceases. The treatment is repeated, and when the liquid is only greenish, it is again heated with dilute hydrochloric acid. The residue is carefully washed and dried, and finally screened.

For making crucibles, &c., the body used contained 10 parts china clay, with 20 parts very refractory fireclay, and 70 parts of corundum (screened through 150 lawn). The body used for making tubes for heating granulated carbon had, instead of the last item, 20 parts corundum screened through 50 lawn, 15 corundum through 20 lawn, and 35 grog (of broken tubes, through 20 lawn). The best results are obtained with corundum free from powder, so that a preliminary fine screening (as through a 100 mesh) is desirable. Both bodies can be moulded.

If the piece should crack, the crack can easily be stopped up with a slightly moist paste, which dries quickly, and, after firing, the added paste and the body of the tube are perfectly joined. Chromium corundum can only be moulded under pressure with the addition of an organic agglomerant, avébene being found specially suitable for this purpose.

Two other varieties of corundum are referred to.

Borocarbon is obtained by fusing bauxite in an electric furnace. The dark-coloured product is very refractory, but it will not resist the action of carbon and carbonaceous materials at high temperatures. The author thinks the presence of a little titanic oxide is the cause of this susceptibility to corrosion.

Alundum supplied by the Norton Company is a good refractory, but it is expensive in France. Moulded tubes of alundum, intended for metal wire resistance furnaces, are not too heavy, but they are brittle, and there is some difficulty in attaching the metal wires firmly at the two ends of the tube. Pressed crucibles have been used successfully.

(To be continued.)

EXPLOSION OF A STEAM STOP VALVE.

A REPORT has been issued by the Board of Trade under the Boiler Explosions Acts, 1882 and 1890, on a Preliminary Inquiry made by one of their Engineer-Surveyors, Mr. J. M. Binmore, Hull, respecting the circumstances and cause of the explosion of a steam stop valve at the works of Messrs. Woodhouse and Rixson, Bessemer-road, Attercliffe, Sheffield, which occurred on January 13. From this report we have obtained the following particulars :—

The stop valve body was of cast iron, spherical in form, with an inlet and an outlet branch, each 4 in. bore, having flanges 11 in. diameter and 1 in. thick. The length between the flange faces was 13 in. The valve was of the usual screw-down type, having a gunmetal valve and seat, 4¼ in. bore. The spindle, nut and packing gland were also of similar material. The makers of the stop valve were Messrs. Alley and Maclellan, Glasgow, and it was some 15 years old. No repairs had been made to the valve, and it was not under any inspection or insurance.

When the accident occurred the inlet branch, fracturing circumferentially at its junction with the flange, allowed the stop valve and connected steam pipe to drop some 4 in, so that the steam was enabled to escape practically without hindrance from the 4-in. branch remaining connected to the main steam line from the boilers, into the crank shop. One of the workmen was incapacitated for some weeks as a result of the failure of the valve.

The explosion was caused by the fracturing of the stop valve inlet branch, due to the material in this branch being subjected by non-alignment of the connected pipe, and severe vibration, to such binding stresses as it was unable to withstand.

In his general remarks on this case Mr. Binmore states that the stop valve was fitted to a branch steam pipe to supply a 4-ton steam hammer, and was connected by means of a cast iron elbow bend to the 6-in. main steam pipe coupling 10 boilers, situated in various parts of the works, which supplied steam at a pressure limited to 80 lb. per square inch. From the stop valve to the hammer valve, connection was made by two lengths of 4 in. solid bore drawn steel pipe ¾ in. thick, their lengths being respectively 15 ft. and 8 ft. 11¼ in. between flanges. The latter length, which was the nearer to the hammer, made a complete circle 3 ft. 9 in. in diameter in a horizontal direction to form an expansion bend. These two pipes were suspended by chain slings to the roof principals to support their weight, but no check to their lateral movement was provided. The foundation on which the hammer was fixed had subsided, so that at the time of the explosion the hammer leaned 4½ in. from the vertical, and the fastening of its bed was such that a considerable amount of oscillation took place when it was at work.

At the time of the explosion the hammer had been at work some hours and the fracture occurred just as a blow was struck. No alteration of any of the conditions applying to the supply of or demand for steam had been made during the night, so that the probability of water hammer action is eliminated.

Since the stop valve was fitted in position some 15 years ago, a length of pipe between the valve and hammer has had to be renewed on two occasions, due to its failure by cracking circumferentially at its junction with the flange. Both pipes which failed were of solid drawn steel, and of similar bore and thickness to that now fitted.

Presuming that the steam pipe was subjected to bending stress when first fitted, with the hammer standing vertical, severe bending stress, the Surveyor adds, must have been transmitted by the pipe to the stop valve when the hammer assumed its oblique position, and these would be greatly intensified by the vibration of the hammer. The metal in the stop valve being subjected to this stress over a long period, ultimately reached such a state of fatigue that failure took place where the casting was of somewhat uneven section, varying from $\frac{7}{16}$ in. to ¾ in. in thickness. The material at the fracture had been sound, but of rather coarse crystalline structure. The hammer has now been replaced in its vertical position, and the Surveyor concludes his report by stating that he is informed that arrangements will be made so to secure the branch steam pipe that no bending stress will be transmitted to the cast iron bend or stop valve.

The following observations are made by Mr. Thomas Carlton, the Engineer-Surveyor-in-Chief, when forwarding his assistant's report to the Mercantile Marine Department of the Board of Trade :—"The conditions were such as might be expected to set up severe stresses in the material of the valve chest. In view of the statement that the steam pipe fractured on two previous occasions, it is not surprising that in consequence of bad alignment, inadequate support and severe vibration, the valve chest should ultimately fracture. Fortunately the direct consequences of the explosion were not serious."

THE GLASGOW AIR-COOLED SLEEVE-VALVE ENGINE.

CONSTRUCTED BY WALLACE (GLASGOW), LIMITED, ENGINEERS, CARDONALD, GLASGOW.

Fig. 1.

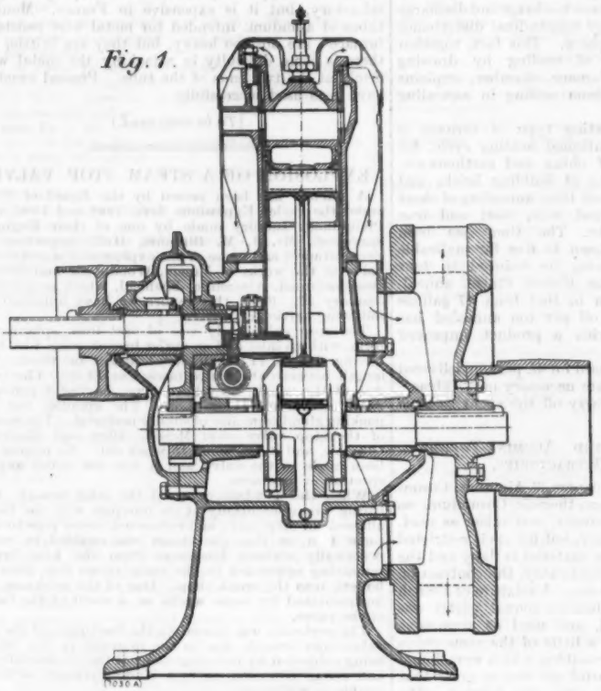
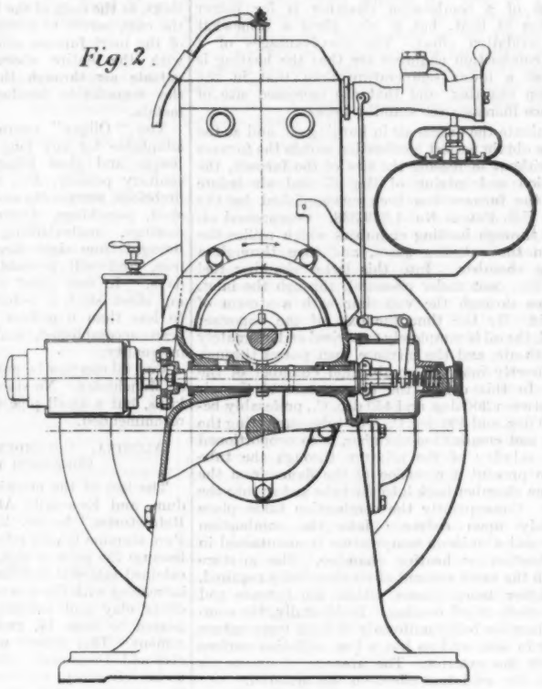


Fig. 2.



A small stationary engine of the internal-combustion type, which embodies numerous features of mechanical interest, is illustrated in Figs. 1 to 3, on this page. The cylinder is air-cooled, but instead of reliance being placed, as is usual on casual draughts or upon a fan blowing air against one side of the cylinder, the designer has tackled the question seriously, and evolved a positive system of air-cooling which appears to be as effective as it is neat. The cylinder is cast with vertical fins which are surrounded by a sheet-metal casing. The flywheel is really a single inlet fan impeller, which draws the cooling air down through the engine and discharges it through the flywheel rim. The incoming air first strikes the top of the cylinder head, before it passes down between the cylinder and the casing, so that the head is effectively cooled. A complete absence of valves in the head is not only advantageous for cooling, but also allows a simple and efficient form of combustion space to be adopted.

The engine works on the four-stroke cycle, the inlet and exhaust being controlled by a sleeve-valve working between the piston and the cylinder. The sleeve valve is operated by a short connecting rod driven from a small crank on the half-time shaft. The link is attached to the sleeve by a vertical pin-joint, which only permits a horizontal motion between the rod and the sleeve. As the rod, therefore, is driven by the crank, the horizontal component of its motion causes the sleeve to rotate, whereas the vertical component compels the sleeve to rise and fall in the cylinder. Any point on the sleeve valve has consequently an elliptical motion relatively to the cylinder walls. The sleeve-valve, near its upper end is pierced with a ring of holes, roughly triangular in shape. These holes cover and uncover corresponding ports in the cylinder, once in every two revolutions of the crankshaft, and thus permit the inlet and outlet of the gases at the proper times. It will be noticed that, owing to the nature of the mechanism driving the sleeve, the latter is never at rest, a feature which is claimed to assist lubrication and to prevent scoring. Unlike poppet valves, moreover, no part of its motion depends upon the action of a spring, and nothing has to be moved against the resistance of a spring.

The cylinder head is detachable, but as the joint is not subjected to the direct heat of the explosions, one of the great troubles of detachable heads is likely to be absent. The half-speed shaft is extended to carry a pulley, which can be used alternatively to the full speed pulley on the main crankshaft when a slower driving speed is required. In the case of the engine illustrated, the cylinder is 3½ in. bore by 4 in. stroke, and 3 b.h.p. is developed with paraffin as fuel. The crankshaft, which is carried in two phosphor-bronze bearings, 1¼ in. diameter by 3 in. long, runs at 900 r.p.m. The two driving pulleys are 6 in. diameter by 4 in. face, and the complete engine weighs 310 lb.

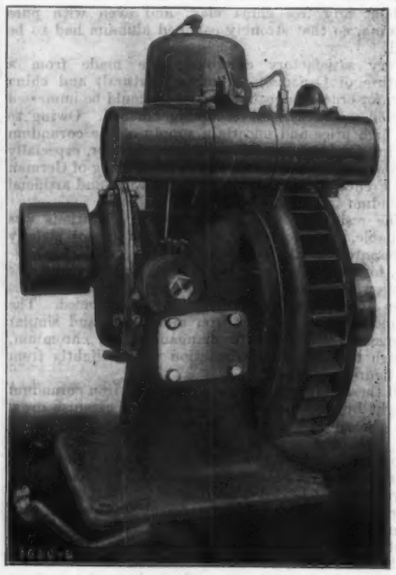


Fig. 3.

The "Glasgow" engine runs very silently, on account of the nature of its valve gear, while the fewness of its parts as compared with four-stroke engines of the ordinary type is an advantage. The design is original, but it appears thoroughly sound from the mechanical point of view. The use of a sleeve valve for a stationary engine is justified by a long experience of such valves in motor car engines, and the peculiar motion of the valve in the "Glasgow" engine appears to be an advance on previous sleeve-valve practice. There are many other features of design which will appeal to engineers, who will appreciate the commonsense solution of many problems concerning which practice had almost become stereotyped. The engine is built by Messrs. Wallace (Glasgow), Limited, of Barfillan-drive, Cardonald, Glasgow, who are the proprietors of the Burt-McCollum patents, under which it is constructed. We may mention that single sleeve-valve water-cooled engines built under the same patents are used as the motive power of the well-known Piccard-Pictet motor cars.

Large Electric Units: Erratum.—Dr. S. Parker Smith wishes us to draw attention to the fact that an error has unfortunately arisen in connection with his paper on "Large Electric Units," read at the recent meeting of the British Association at Edinburgh. In this paper, which was reproduced in our issue of September 16, the design of water wheel rotor illustrated in Fig. 20, page 402, should have been credited to the Maschinenfabrik Oerlikon, and not to the S.A.C.M., and the reference to the latter firm towards the foot of the third column of page 399, in connection with Figs. 19 and 20, should have been omitted.

The Institution of Automobile Engineers.—The annual dinner of this Institution will be held at the Royal Automobile Club on Wednesday, October 26, and tickets, price 15s. each, for members and male guests are to be obtained from the secretary. We are informed that 14 entries have been received for the annual premium offered by the Daimler Company for the best graduates paper of the session. A further prize for graduates is announced, namely, the sum of three guineas to be given by Dr. W. R. Ormandy to the graduate who is judged by the vote of his fellows to have taken the most useful part in the discussions during each session.

Airship Memorial Fund.—In order to commemorate the officers and men lost in the R. 38 and other airships, the Council of the Royal Aeronautical Society has decided to establish a memorial fund, the income from which will be used to encourage investigations of problems connected with airships or allied subjects. The results of such work are to be embodied in papers to be read before the Royal Aeronautical Society, as it is thought that this proposal offers the best means of carrying on the work of those whose lives have been lost in the development of airships. Moreover, as the Government has decided to suspend all work on airships and is making no provision for experiment or research, the council feel that, if this country is not to drop completely out of the race for supremacy in commercial airships, some such work should proceed, even if only on a small scale. They therefore appeal for subscriptions to the fund from which it is hoped to be able to provide an annual grant towards the carrying out of some specific investigation, the nature and extent of the work naturally being dependent on the sum available. Contributions to the fund should be forwarded to the Secretary, the Royal Aeronautical Society, 7, Albemarle-street, London, W. 1.

MULTIPLE GEAR-SHAPER.

CONSTRUCTED BY THE STEVENSON GEAR COMPANY, INDIANAPOLIS, IND., U.S.A.

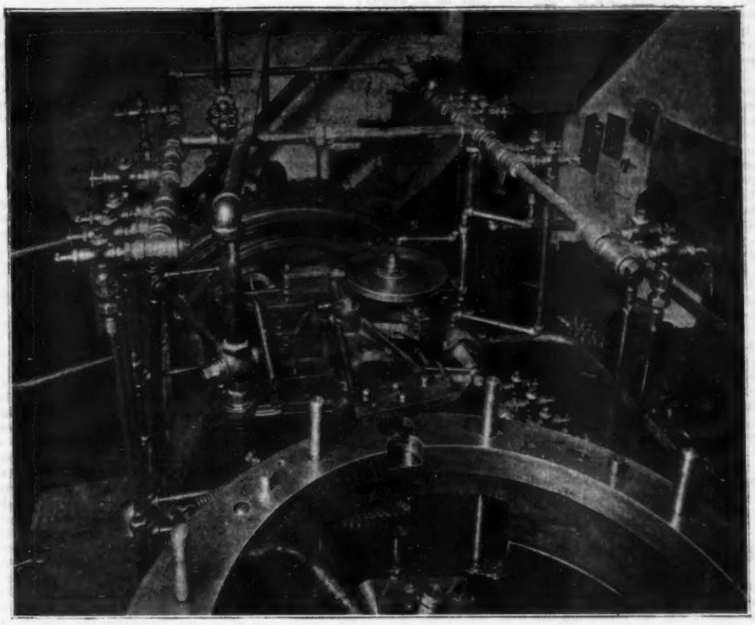


FIG. 1. FEED AND CLAMPING GEAR FOR TOOL HEAD.

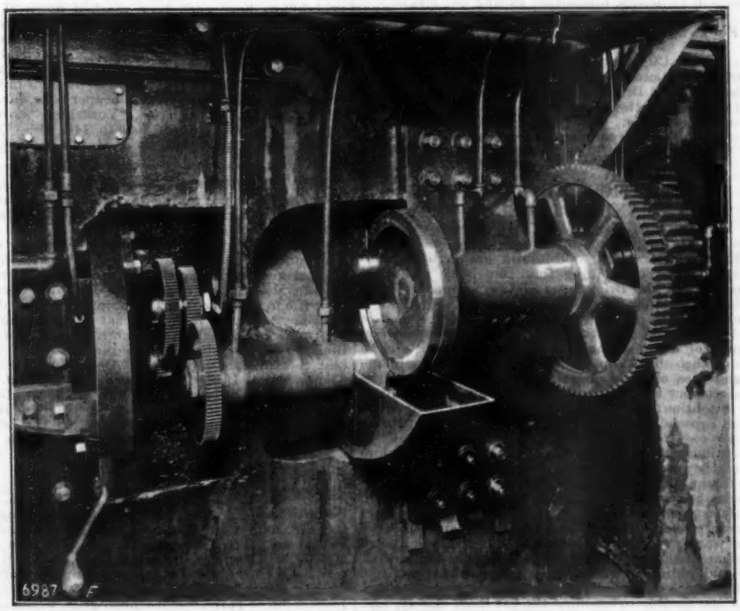


FIG. 2. THE INDEXING GEAR.

A MACHINE tool of a distinctly novel character has been recently brought out by the Stevenson Gear Company, of Indianapolis, Ind., U.S.A., and is illustrated in Figs. 1 to 6 on this page and page 542. The machine is a gear shaper, and is intended for multiple or gang work, while its special features enable particularly fast times to be attained. A general view of the machine is shown in Fig. 3, page 542, which, however, scarcely does justice to the unique characteristics of the tool. Briefly, the machine employs a large number of cutting tools arranged radially round an opening through which the work blank is alternately raised and lowered on a vertical ram. The work is reciprocated vertically at the rate of 50 strokes per minute, while the feed to the tools, indexing, &c., are automatic. The machine stands about 7 ft. high and is driven by a 100-h.p. motor, the control being by push-button.

The tool head and vertical ram are contained in the cylindrical part of the body, which is seen in Fig. 3 at the far end of the machine, and is again illustrated in Fig. 4. The reciprocating motion of the ram is obtained from a crank at the end of an horizontal shaft driven through reducing change gears from the motor. The main crankshaft is connected to the large gear shown in Fig. 3 by a quick return motion of the drag link type. This may also be seen in Fig. 3. It gives to the ram a slow motion on the upward or cutting stroke, and a quick return on the downward idle stroke of the ram. The work arbour is carried in a spindle in turn carried by the ram, and made to rotate under the control of indexing gear. After each stroke and before the next cut the work is indexed through one tooth space, thus bringing a fresh tool into contact with each tooth at each cut.

The tool head presents many interesting points. We give two views of it in Figs. 5 and 6. Both these are taken of the underside of the head on being lifted off the machine, this operation being readily performed by means of an overhead block and sling, the latter engaging with two lugs specially provided on the head for this purpose. The head consists of a flat steel disc 3 ft. in diameter, having a hole in the centre through which, as explained, the work reciprocates up and down. On the underside the disc is provided with a number of radial grooves, in which the cutting tools are disposed round the central opening. Fig. 5 is a view of the tool head with tools in position and the bottom cover plate in position. The other illustration, Fig. 6, shows the cover plate removed and exposes to view the radial cutting tools and the feeding mechanism. The general principle of the feed to the tools will be at once gathered from this view.

The cutting tools are rectangular in section except that one side is vee'd. The cutting tip is ground to the profile of the tooth to be cut and is backed off so that it can be re-ground without changing the form. It is frequently advisable to grind alternate tools to shape the root and top of the teeth to be cut. At the outer end each tool shank is provided with a pin which fits into a spiral groove, while the butt of the shank rests up against a spiral cam face. The latter serves to feed the tool in towards the centre, while the former is employed to draw the tool off, in connection with the relief for the idle stroke. The feed cams are all mounted on a large ring, and each is held down on a spacing ring by three tee bolts. The cutters are adjusted individually for depth by these cams being moved circumferentially in the setting. Simultaneous feed is given to all cutters, by a toothed sector shown in Fig. 1, which we shall refer to later, through the small idler gears shown at the lower part of the tool head in Figs. 5 and 6. The depth to which the cut is finally taken is fixed by an adjustable stop which prevents further rotation of the cam ring. The position of this stop can be varied within limits so that some latitude in cut is possible where the tools have not been set for exactly the correct depth in the first instance, or have suffered wear. The relief on the return stroke is obtained by reversing the direction of movement of the cam ring, and before commencing the next cut the forward movement is sufficient to take this up and in addition provide the necessary additional feed.

The large toothed disc shown on the head in Fig. 5 provides the means for clamping the tools during the cutting stroke. The disc is in two sections, a central portion which is bolted to the head, and in which there are screws bearing on the tools, and an outer annular portion. The latter screws into the head by means of a flange of large diameter and fits inside the raised rim seen in Fig. 6. By means of a toothed sector, which is best shown in Fig. 1, this annular plate is screwed up during each upward stroke of the work arbour, and slightly unscrewed on each return stroke. This forces the central plate to hold the tools tightly in their vees, while cutting, and releases them for the relief while idle.

The feeding and clamping gear-toothed segments are seen as already noted in Fig. 1. The former, on a level with the top of the large studded flange in the foreground, is directly operated by a disc cam combined with a ratchet plate immediately below the disc. The slight relief movement is provided by mounting this sector on a fulcrum pin which is eccentric on a shaft which is partially rotated by a lever and plunger, the latter being actuated by a face cam on the large crank gear face, as seen in Figs. 1 and 4. The clamping toothed sector is seen in Fig. 1 projecting through an opening in the side of the cylindrical body of the machine. It is operated by a spring and cam-operated plunger, the former providing the grip during the cutting stroke, while the latter relieves it for the return stroke. The plunger is worked by a second cam on the large crank gear.

Two tool heads are furnished with each machine, and while one is in work on the machine the other may be re-tooled and set for a fresh job. The head is easily removed from the machine, being held down by eight bolts, and being capable of being slung by an overhead block, on lugs to which we have already referred.

The indexing gear is shown in Figs. 2 and 4. The intermittent motion is secured by the introduction of the Geneva wheel shown in Fig. 4, and this is transmitted to the rotating spindle on the ram by means of the worm gear shown in Fig. 4. The gear ratios in this train can be varied to suit the job. A differential clutch between the worm and worm shaft enables small adjustments of 1 second to be made on the spindle.

The work arbour is long enough to accommodate several blanks which are held by a nut and washer. The shank of the arbour is tapered, and fits into a

tapered socket in the revolving spindle of the ram. The cutting stroke being the upward one, the arbour is pressed fast into the socket, the taper being such, however, that it can be easily removed. With spare arbours it is possible to prepare new blanks for cutting while one set is on the machine, the actual insertion in the machine taking only a moment to accomplish.

The operator has an almost unlimited choice in the tooling of the head. For some gears he may use as many tools as there are teeth to be cut; in other cases he need only use a fraction of them. Again, in fine tooth gears he may use tools cutting two or more teeth instead of one only. Odd numbers of teeth may be cut by dividing the circle into 10 spaces, 9 of which are equal, the remaining 1 being smaller in the required proportion.

The machine will cut teeth, splined shafts, cutters, ratchets, saws, &c. All the tools cut simultaneously, and the time to finish is thus greatly reduced as compared with that of the ordinary gear shaper. On the usual gear hobber, 3 in. diameter sprockets with 12 teeth at ½ in. pitch, mounted 16 on an arbour, may take 16·6 minutes to produce, or 1·04 minutes per piece. The time claimed for the Stevenson machine is 3·7 minutes, or 0·23 minute per piece. Other equally remarkable times are reported, the multiple cutters greatly accelerating the cutting process. At the same time the method of cutting by several tools radially disposed produces no spring on the arbour, and the capacity of the machine is not limited through this cause.

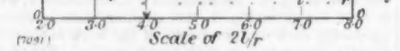
"STRESSES IN SHIPS' PLATING DUE TO FLUID PRESSURE."

To the Editor of Engineering.

Sir,—Since reading Dr. Laws' letter in your issue of September 30, I have referred to my previous letter and find that my only adverse criticism of Dr. Laws' paper had reference to some of his deductions from his theoretical investigations on free-ended stiffeners and to Fig. 6, which referred to rigid boundaries. I will confine my remarks to Fig. 6, which I have described as "misleading."

The diagram, Dr. Laws tells us, was not to scale and was qualitative and not quantitative. I had taken it to be to scale, and since no value of n was given for the curves in the diagram I had assumed that it represented Dr. Laws' ideas regarding the actual panels illustrated. The qualitative curves from my study of the problem I was convinced were incorrect for all practical panels of ship's plating and did not represent even an average panel.

I have drawn out a curve illustrating the effect upon the maximum stress in the plating of dividing a panel



with rigid boundaries of length $2l$, and width r, into two panels of length l, and width r, by a rigid boundary. For a given value of r the reduction of stress is a *maximum* when $l = r$ (example quoted by Dr. Laws). His qualitative diagram showed a reduction of 66 per cent. against *the maximum possible* of 57 per cent. Had l and r been both halved the reduction would have only been 75 per cent.

Further examination of the curve, which has been deduced from Dr. Laws' own formula for (n), shows that when $\frac{2}{r}l = 2{\cdot}5$ the maximum stress is halved by halving the panel; when $\frac{2}{r}l = 6$ halving the panel brings the reduced panels to the proportions obtaining in ship practice and only reduces the maximum stress by about 20 per cent.

The whole problem is a most important one for the shipbuilder and needs to be investigated on the lines that Dr. Laws has followed, but now by careful experiment also.

Yours faithfully,
T. B. Abell.
The University of Liverpool, School of Naval Architecture, October 6, 1921.

PROFESSOR LEA AND THE SEVERN TIDAL POWER PROJECT.

To the Editor of Engineering.

Sir,—It is only to-day that I received my copy of your issue of the 16th ult., in which appears a verbatim report of the paper read before Section G of the British Association at the recent Edinburgh meeting, by Professor F. C. Lea, on the "Utilisation of Tidal Power." Will you allow me to make a brief comment on this address? In his opening remarks Professor Lea says: "Since the last meeting of the British Association, definite proposals have been put forward by the Ministry of Transport, which practically embody those made by Messrs. Addenbrooke, Meik and Twinberrow, when giving evidence before the commission of inquiry on available sources of water power. The proposals are related, in this particular case, to the developing of improved means of communication of the neighbourhood." I am not acquainted with the details of the proposals made by the three gentlemen named, though we seem to be left by Professor Lea to conclude that he is about to describe them. What I do know, however, is that the hydraulic power storage project described by Professor Lea and occupying the principal place in his address, is mine, put by me, in considerable detail, before the "commission of inquiry on available sources of water power." My proposals included "the developing of improved means of communication of the neighbourhood—in my plans (some of which were reproduced for the use of members of the Commission, who were rather numerous), in my memoranda and in my evidence, that feature of my project was emphasised. My project is mentioned at the same time and in the same fashion as that of Messrs. Addenbrooke, Meik and Twinberrow, in the third interim report of the committee.

Moreover, before there was a Water Power Resources Committee I applied for a patent for the high level tidal power storage system described by Professor Lea, and forming an essential feature of the great scheme set out by the Ministry of Transport. The patent was duly granted, is still in force and still belongs to me. I believe it covers a necessary feature of any tidal power project, ever likely, in our present state of knowledge, to be commercially successful.

As I had no professor to blow my trumpet at the Edinburgh meeting—Professor Gibson, the president of Section G, as a member of the Water Power Resources Committee is aware of all that I have stated—I hope that you will permit me this modest "tootle" in your columns.

Yours, &c.,
A. J. Liversedge, A.M.Inst.C.E.
National Liberal Club, Whitehall, S.W. 1,
September 28, 1921.

THE YELLOW RIVER BRIDGE CONTRACT.

To the Editor of Engineering.

Sir,—We have read Mr. Moore Bennett's letter on page 517 of Engineering for October 7, 1921. As our tender is the only English one mentioned on the list given, the remarks must be taken as applying to it.

The facts given you are not correct. Our tender was for manufacture and erection of the whole bridge complete, including foundations, and was most fully detailed out both as to design, quantities, pricing and terms.

Yours faithfully,
For the Cleveland Bridge and Engineering Company, Limited.
Charles F. Dixon, Managing Director.
Darlington, October 12, 1921.

[The Cleveland Bridge and Engineering Company have sent for our inspection a copy of their tender and accompanying documents. The tender is exceedingly well drawn up and is very complete in every respect.—Ed.E.]

THE RETICENCE OF BRITISH MANUFACTURERS.

To the Editor of Engineering.

Sir,—I see in the issue of Engineering for September 30 two letters from well-known gas-engine manufacturers, both complaining that somebody who read a paper before the British Association seemed to have the impression that if one wanted a large gas engine it was necessary to go to Germany for it. Such a lack of knowledge of the industry is, of course, inexcusable on the part of anyone who thinks himself competent to speak on the subject, but I think that much of the blame for ignorance of their products lies at the door of the manufacturers themselves. If they would pay a little more attention to the question of making their work known, especially in overseas markets, and would take care to see that they were properly represented in publications which profess to keep their names before buyers, they would secure many orders which now go to their foreign competitors.

During the last few days, when making a list of British manufacturers of steam boilers, I turned to a certain "directory of merchants, manufacturers and shippers of the world," having been told that it was a standard and comprehensive publication, which would contain the name and address of every boiler maker in this country. Not finding there the name of a firm I expected to see, I took the trouble to examine the list more closely, and discovered many other omissions of firms whom I have reason to believe are considerable builders of steam boilers. The directory I consulted is probably the best of its kind in existence, and if such a work, which is no doubt largely used by overseas merchants, omits to include important manufacturers in its classified lists, is the overseas buyer to be blamed if he is unaware of their existence? I fully realise the difficulties which the compilers of such a work encounter when dealing with the classification of engineering firms, and I do not blame them so much as the firms who are omitted from their rightful place. If British manufacturers will not take the necessary care to see that the purchasing public both here and abroad are kept properly informed concerning their lines of production, they have no right to complain when their existence is ignored. Their advertisements, too, might with advantage, be more informative. The overseas buyer of boilers, for example, wants to know what kind of boilers each advertiser specialises on, what sizes he is prepared to build and so on. I am firmly convinced that anything of an engineering nature can be obtained in England better than anywhere else in the world, but it is often a most terrible job to find out where to get it.

I am, Sir, yours truly,
Member of the Engineering Institute of Canada.

NOTES FROM SOUTH YORKSHIRE.

Sheffield, Wednesday.

The Steel Outlook.—Addressing the shareholders of the United Steel Companies, Limited, Mr. A. O. Peech, chairman of directors, said there was no reason to be unduly pessimistic. The partial restarting of works was gradually broadening, and there was good ground for the opinion that improvement would steadily continue. It must be obvious to every thinking man, however, that in the present circumstances of trade, the improvement could not be rapid.

Iron and Steel.—While a more optimistic spirit seems to have gripped the heavy engineering and steel trades, it is difficult, if not impossible, to find any section of local industry where production is expanding. Only a small percentage of foreign inquiries for steel and steel products is materialising in orders. Prices generally are too high to attract new business, largely owing to exchange differences on the Continent. Electrical apparatus and textile machinery for export occupy the best position in regard to future working, but the steel-producing sections are badly in need of a fillip. Temporary arrangements made in the crucible and allied trades some few months ago, to secure cheaper production, have not resulted in any considerable influx of business. In these circumstances it is likely that, in the early future, wages will again come under review, unless the trade unions can be induced to abandon restricting practices and to encourage increased output. The placing of British Admiralty orders is exciting a good deal of speculation, though from the number of firms that have submitted contracts it is evident that Sheffield armament departments are well represented, and that directly and indirectly a good proportion of the work required will be secured locally. Quieter conditions obtain in the engineering and tool trades, though some useful orders have come to hand for tool and magnet steel, and valuable contracts are under completion for shipment to Russia. Many furnaces and rolling mills are being run at a loss, pending the possibility of an early improvement. Open-hearth departments are working at less than two-thirds their normal capacity. Following the cut of 3*l.* per ton in high carbon acid billets for the file-making trade, Bessemer and Siemens acid billets have each been marked down 2*l.* per ton, bringing the current quotations respectively to 13*l.* 10*s.* and 14*l.* Business in soft basic steel is exceptionally scarce, with the result that there is a good deal of selling pressure and wide variation in quotations, which range from 7*l.* 10*s.* to 9*l.* 10*s.* Makers of semi-finished and finished iron, benefiting from cheaper coke, have made a further adjustment in rates. Yorkshire "crown" bars have been marked down 30*s.* to 14*l.* 10*s.* Derbyshire foundry iron is quoted as low as 6*l.* 10*s.* and forge quality at 5*l.* 15*s.*

South Yorkshire Coal Trade.—Home consumers of steam hards are not taking anything like normal supplies, and shipments are on a limited scale. Collieries find difficulty in clearing their sidings. Cobbles and nuts are weak. Despite the reduction in prices, industrial fuel generally goes away very slowly. A slightly increased interest is shown in slacks, but the volume of business done leaves much to be desired. There is very little life in the coke industries; prices have a downward tendency. Trade in house coal is benefiting from an improved demand from the metropolitan area. Quotations: Best branch handpicked, 40*s.* to 41*s.*; Barnsley best Silkstone, 40*s.* to 41*s.*; Derbyshire best brights, 35*s.* to 36*s.*; Derbyshire house coal, 34*s.* 6*d.* to 35*s.*; Derbyshire best large nuts, 32*s.* to 33*s.*; Derbyshire small nuts, 29*s.* to 30*s.*; Yorkshire hards, 31*s.* 6*d.* to 32*s.* 6*d.* Derbyshire hards, 30*s.* 6*d.* to 31*s.* 6*d.*; rough slacks, 17*s.* to 18*s.*; nutty slacks, 16*s.* to 17*s.*; smalls, 5*s.* to 10*s.*

Occurrence of Petroleum in Nature.—A new Department of Petroleum Technology was inaugurated at the Sir John Cass Institute, E.C., last Monday by a lecture on "The Occurrence of Petroleum in Nature." Mr. E. H. Cunningham Craig, B.A., F.R.S.E., F.G.S., was the lecturer, and the chair was appropriately taken by Sir Frederick Black, last year's president of the Institution of Petroleum Technologists, which is exerting itself in procuring a proper training for petroleum technologists in this country. Coal, oil shale and gas, Mr. Cunningham Craig pointed out, occurred under similar conditions, on the flanks of the great, old and newer mountain ranges, the oil further out in the less disturbed regions than the coal. When oil layers were raised by earth movements, oil shales were formed when the colloidal liquid was adsorbed and inspissated (*i.e.*, thickened by evaporation); the shale indicated that oil might still be found at a greater depth; though seepages of lighter oil might also be observed. The anticlinal dome structure was not essential. It was a fallacy always to look for superposed layers of water, oil and gas which only occurred under ideal conditions. It was also a fallacy that oil migrated and disappeared by the fault planes; that was confounding a geological fault and a fissure. Moreover, oil might migrate in any direction. The belief that oil had originated in marine beds from animal organisms was chiefly based upon the study of the Carpathian fields, but had not proved tenable elsewhere.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Business in Cleveland pig-iron is on a very limited scale. Continued acute scarcity of No. 3 g.m.b. enables sellers to uphold values of that quality at 120*s.* for home purposes, and 125*s.* for shipment to foreign destinations, but No. 4 foundry is now on sale at 114*s.*, whilst the inferior grades are so plentiful as to be quite a drug upon the market, with the result that it is difficult to ascertain on how much lower terms than the recognised market rates, orders would be accepted. No. 4 forge and mottled are each put at 112*s.* 6*d.*, and white iron at 110*s.*

Hematite.—Supply of East Coast hematite is rather considerably in excess of requirements, and as a consequence quotations are falling. Home demand, generally, is on a very moderate scale, and inquiries on Continental account are quite trifling. Nos. 1, 2 and 3 are stated to be now obtainable on both home and export account at 125*s.* No. 1 is put at half a crown above mixed numbers.

Blast-furnacemen's Wages.—The average net selling price of No. 3 Cleveland pig-iron for the three months ending September 30 last has been certified at 131*s.* 5·13*d.* per ton, as compared with 126*s.* 11·56*d.* for the previous quarter. There was thus an advance in price of 4*s.* 5·57*d.* per ton in the third quarter of the year, which means an advance in North of England blast-furnacemen's wages of 4·50 per cent. This raises wages from 72·75 per cent. above the standard, to 77·25 per cent. above the standard.

Foreign Ore.—Consumers of foreign ore are not in the market to buy, as they still hold heavy stocks, and have large supplies to come forward on old contracts. With the exception of the sale of an odd cargo, business is at a standstill, and the quotation of 28*s.* c.i.f. for best rubio is more or less nominal.

Coke.—There is not much doing in coke, but with sellers of Durham blastfurnace kind at 31*s.* delivered, the value is getting near local consumers' idea of 30*s.*

Manufactured Iron and Steel.—On a falling market finished iron and steel buyers are not to be found. A feeling prevails that so soon as there is reason to believe that bottom quotations have been touched, considerable briskness will be experienced. Current home quotations, all of which would be cut for export orders, stand:—Common iron bars, 14*l.*; marked bars, 18*l.*; steel billets, 10*l.* 10*s.* to 11*l.*; steel boiler plates, 19*l.*; steel ship, bridge and tank plates, 14*l.*; steel angles, 13*l.* 10*s.*; steel joists, 13*l.* 10*s.*; rounds and squares, 13*l.*; flats, 14*l.*; heavy steel rails, 12*l.* 10*s.*; fishplates and sleepers, 17*l.* 10*s.*; black sheets, 15*l.* 10*s.* to 16*l.*; galvanised corrugated sheets, 19*l.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—No change has taken place in the state of the Scottish steel trade, and the past week has been a very lean one as regards new business. The bookings have recently been very small, and hand-to-mouth conditions are all too general, and instead of plant in operation being increased gradually the opposite is the case, and in some works a slowing-down process is in vogue. The industrial depression is being keenly felt in the steel trade, and there are few buyers of steel material at the present time. Prices are all against any buying movement, but the moment any further reductions can be made the various producers will at once revise their quotations in the hope of securing new orders. The number of inquiries is really quite good, but the actual outcome is not very encouraging. Export business is of very small proportions just now. The makers of black sheets are very quiet, but inquiries point to the fact that there is quite a lot of very probable business in the near future, but most of it depends on prices being brought down a bit further. Current prices are: Ship plates, 14*l.* per ton; boiler plates, 19*l.* per ton; sections, 13*l.* 10*s.* per ton; and sheets, $\frac{7}{8}$ in. to $\frac{1}{4}$ in., 15*l.* 5*s.* per ton, all delivered at Glasgow stations.

Malleable Iron Trade.—The dullness in the West of Scotland malleable iron trade continues, and despite every effort to increase sales the different works are very slack. Little business has followed the last reduction in prices, and even with "crown" bars now quoted at 14*l.* per ton buyers are holding out of the market still, and only actual necessities have been booked. The Continental makers' prices continue low, and so heavy have been their bookings in recent months that they are ensured steady running well ahead and cannot now give promise of early deliveries. This state of affairs will have a beneficial effect on local works in the near future.

Scottish Pig-Iron Trade.—Weakness still characterises the Scottish pig-iron trade, and the general tone is not quite so good this week. Dealing is of a very limited nature, but this cannot be wondered at when there is so much idleness throughout the country and so many industrial concerns on short time. The number of furnaces in blast is gradually being increased, and producers are preparing for the day when trade begins to improve. Export lines are difficult to pick up, and only small lots are being shipped. Prices have an easier tendency, and the following may be taken as to-day's quotations:—Foundry No. 1, 7*l.* 10*s.* per ton; No. 3, 7*l.* 5*s.* per ton, on trucks at makers' works; and hematite, 7*l.* 7*s.* 6*d.* per ton, delivered at the steel works.

Shipbuilding.—The shipbuilding returns for the past month are very satisfactory, but scarcely give a true index of the industry as a whole. The figures for the different districts in Scotland are as follow:—

	Vessels.	Tons.
The Clyde	16	50,152
The Forth	1	3,700
The Tay	1	800
The Dee and Moray Firth ...	—	—
Total	18	54,652

The increased output is due to the return of the shipyard joiners to work, and they have been very busy since they resumed and have still a lot of work to get through. The Clyde total is the third highest for the year, and is the best since March, when the output was 56,410 tons. For the nine months the Clyde figures are 181 vessels of 350,016 tons, which is the lowest total since 1910, when the output was 226 vessels of 342,631 tons for the corresponding period. New contracts are still very scarce, and very few are reported as the costs are too high yet to permit of shipping firms entering the market.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

The Coal Trade.—Market operators are still waiting the decisions of Sir William Plender, independent chairman of the National Coal Board, in respect to the wages liability of the South Wales coalowners for September and the basis of calculation of the October wages. The points in dispute are of vital importance to the coal owners, for they involve something like 7*s.* per ton in the cost of production. The contention of the Mines Department of the Board of Trade and the coal owners in respect to the September wages, and of the Miners' Federation and the coal owners with regard to the October wages were placed before Sir William yesterday, in London, and he has promised to give his rulings on Friday or Saturday. Another important matter which is receiving attention is the question of dock and railway charges in connection with the loading and carrying of coal. The Bristol Channel Dockowners' Association have considered an application from traders for a reduction in rates, and to-day the dock owners are meeting representatives of the South Wales Coalowners' Association in London, when it is expected a definite decision to reduce rates will be made. In the meantime business on the coal market is quiet, and though many collieries are idle or working short time, sellers experience difficulty in disposing of outputs. This is particularly the case in respect to large coal. Best Admiralty is freely obtainable at 30*s.*, and in some cases a little less, second Admiralty from 28*s.* 6*d.*, best Monmouthshires 27*s.* 6*d.*, Eastern Valleys 26*s.*, and No. 2 Rhondda large 25*s.* Sized coals are scarce owing to the numerous pit stoppages, and dry nuts, which are being used as a substitute for anthracites, are almost unobtainable at 35*s.*, but bituminous nuts are freely available at 27*s.* 6*d.* Smalls of most descriptions are tight, with some sellers refusing to sell without a proportion of large except at a premium. Prices are steady, with best steams worth 19*s.* to 20*s.*, ordinaries 17*s.*, cargo sorts 15*s.*, and good dry smalls 13*s.* to 14*s.*

Iron and Steel.—There has been an increase in the volume of business in the Welsh tin-plate trade. The unexpected reduction in the price of Welsh bars stimulated buying on speculative account, and prices are rather firmer for forward delivery. For standard boxes, 21*s.* to 22*s.* is quoted for prompt delivery, and for forward 21*s.* The galvanised sheet market is firmer with 24-gauge corrugateds in bundles firm at 19*l.* to 20*l.* A large shipment has for the first time just left Swansea direct for India, and another cargo is due out. In the past these shipments have been made *via* Liverpool, or Newport.

THE INSTITUTION OF NAVAL ARCHITECTS.—The following scholarships in naval architecture and marine engineering have been awarded by the Council of the Institution of Naval Architects, viz: *Naval Architecture*: Fairfield scholarship (150*l.* per annum), to Mr. A. Mitchell, of Messrs. Armstrong, Whitworth and Co., Newcastle; Beardmore scholarship (150*l.* per annum), to Mr. F. W. Green, of Messrs. Harland and Wolff, Belfast. *Marine Engineering*: Weir scholarship (150*l.* per annum), to Mr. Edward Steel, of Messrs. Richardson, Westgarth and Co., West Hartlepool; Yarrow scholarship (100*l.* per annum), to Mr. C. R. Cooper, of Messrs. Harland and Wolff, Glasgow.

PERSONAL.—Messrs. Higgs Brothers, of Sand Pits, Birmingham, have recently opened a London office, at 265, Strand, London, W.C. 2, for the sale of the small motors and dynamos of their manufacture, of which they carry in stock a very large range of sizes, the prices of which have been substantially reduced.—We are informed that Mr. Charles Good has retired from the firm of John Fowler and Co., Limited, after a connection of nearly thirty years with their London office. Mr. Good started his career with the firm in the early days of municipal electric lighting, and in a short time succeeded in obtaining contracts for a large share of the orders then placed in this country for central station equipment. At the outbreak of war, he volunteered his services to the War Office and later to the Ministry of Munitions, where for four years he was in constant touch with the departments dealing with the supply of road transport for the haulage of heavy artillery.—The British Chamber of Commerce, Paris, informs that the British Consulate-General in Paris has now moved to new quarters at 7 bis., Rue Lord Byron, Paris 8.—Captain M. G. Kiddy, who has for the past two and a-half years held the position of assistant secretary to the Society of Architects, has just been appointed secretary to the Concrete Institute.

NOTICES OF MEETINGS.

THE BRADFORD ENGINEERING SOCIETY.—Monday, October 17, at 7.30 p.m., Lecture in the Hall of the Bradford Technical College. Mr. S. N. Brayshaw, M.I.Mech.E. (of Manchester), on "The Heat Treatment of Tool Steels," illustrated by lantern slides and actual examples.

THE INSTITUTION OF AUTOMOBILE ENGINEERS.—Tuesday, October 18, at 7 p.m., the second Ordinary Meeting of the Birmingham section of the Institution of Automobile Engineers will be held at the Chamber of Commerce, New-street, Birmingham, when Mr. H. D. Teage will read a paper entitled "The Development of the Single-Cylinder Solo Motor Cycle."

SOCIÉTÉ DES INGÉNIEURS CIVILS DE FRANCE.—BRITISH SECTION.—Wednesday, October 19, 1921, at 8 p.m., at the Institution of Mechanical Engineers, Storey's Gate, S.W. 1. At 7.30 p.m. a social gathering of members, after which a paper will be read at 8 p.m. on "Tanks and Chain-Track Artillery," by Mr. L. A. Legros, Member, M.I.C.E., M.I.M.E., M.I.E.E., M.I.A.E. The paper will be accompanied by slides and kinematographic films.

THE SOCIETY OF GLASS TECHNOLOGY.—Wednesday, October 19, at 2.45 p.m., in the Mappin Hall, Applied Science Department, Sheffield University. The president will speak briefly on "The Work of the New Session"; papers will be read and discussed as follows: "Properties of the Lime-Magnesia Glasses and their Commercial Application," by Mr. V. Dimbleby, Mr. S. English, Mr. F. W. Hodkin and Dr. W. E. S. Turner; "The Composition, or Comparative Composition of Glass-House Pots in Olden Times," by Mr. G. V. Evers.

THE NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS.—Wednesday, October 19, commencing at 7.30 p.m., in the Lecture Theatre of the Literary and Philosophical Society, Newcastle, when Major-General Sir Sefton Brancker, K.C.B., will deliver a lecture entitled "The Position of Aviation To-day."

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, October 21, at 6 p.m., Eleventh Report of the Alloys Research Committee: "On Some Alloys of Aluminium," by Mr. Walter Rosenhain, B.A., D.Sc., F.R.S., Mr. Sydney L. Archbutt, F.I.C., and Mr. D. Hanson, D.Sc.

THE JUNIOR INSTITUTION OF ENGINEERS.—Friday, October 21, at 8 p.m., at Caxton Hall. Lecturette, "Pyrometry for Boilers; Some Questions, Pertinent and Impertinent," by Mr. C. E. Foster (Member).

THE MIDLAND INSTITUTE OF MINING, CIVIL AND MECHANICAL ENGINEERS.—Saturday, October 22, at 2.30 p.m., in the South Grove Secondary School, Moorgate, Rotherham, when the President's address will be delivered and the following paper will be open for discussion: "Friction Coefficient of Minerals," by Mr. S. Nettleton. A demonstration by means of a working model of the "Spiral Separator" for the dry separation of dirt from coal will be given by Hugh Wood and Co., Newcastle-on-Tyne.

TELEPHONES IN GREECE.—In is proposed to install additional telephone facilities in Athens, comprising a central battery system with about 5,000 local, 40 inter-urban, and at least 50 special lines connecting with the Piræus. The adjudication is to be made on November 14, and copies of plans and other particulars may be consulted at the Department of Overseas Trade (Room 49), 35, Old Queen-street, S.W. 1.

THE ASSOCIATION OF ENGINEERING AND SHIPBUILDING DRAUGHTSMEN.—We have received from the Merseyside branch of this association a small booklet giving the syllabus of lectures for 1921–22. These commenced on the 7th inst. and are to continue to February 23, the next one being on the 21st inst., when Mr. A. T. Wall, M.I.N.A., will deal with "The 'Kitchen' Rudder." The general secretary of the association is Mr. P. Doig, 96, St. George's-square, London, S.W. 1.

THE INSTITUTION OF RUBBER INDUSTRY.—This Institution, in issuing the syllabus of the winter session, 1921–22, states that the first meeting will be held at the Society of Arts, John-street, Adelphi, W.C. 2, on Wednesday, the 19th inst., at 7 p.m., when Mr. J. H. C. Brooking will deliver his presidential address. Sir Henry Wickham will read a paper on his "Experiences when Sowing the Seeds in Brazil in 1876 which Originated the Rubber Plantation Industry in the East," and Mr. Herbert Rogers will deal with "Rubber Manufacture." The syllabus gives the list of papers to be read at later dates. Further particulars can be obtained from the Institution offices, Charing Cross House, Charing Cross-road, W.C. 2.

PRODUCTION OF PIG IRON AND STEEL IN SEPTEMBER.—Production of pig iron in September amounted to 158,300 tons, compared with 94,200 in August, 386,000 in March and 741,000 in September, 1920. Of the pig iron produced, 47,400 tons were hematitite, 48,100 tons were basic, 49,100 tons foundry, 10,700 tons forge and 3,000 other qualities. The number of blast furnaces in operation, which had been 15 at the end of July and 47 at the end of August, was 67 at the end of September. The number in blast at the end of September, 1920, was 300. The production of steel ingots and castings in September amounted to 429,900 tons, compared with 434,100 tons in August, 359,100 tons in March and 884,700 tons in September, 1920.

MULTIPLE GEAR-SHAPER.

CONSTRUCTED BY THE STEVENSON GEAR COMPANY, ENGINEERS, INDIANAPOLIS, IND., U.S.A.

(*For Description, see Page* 539.)

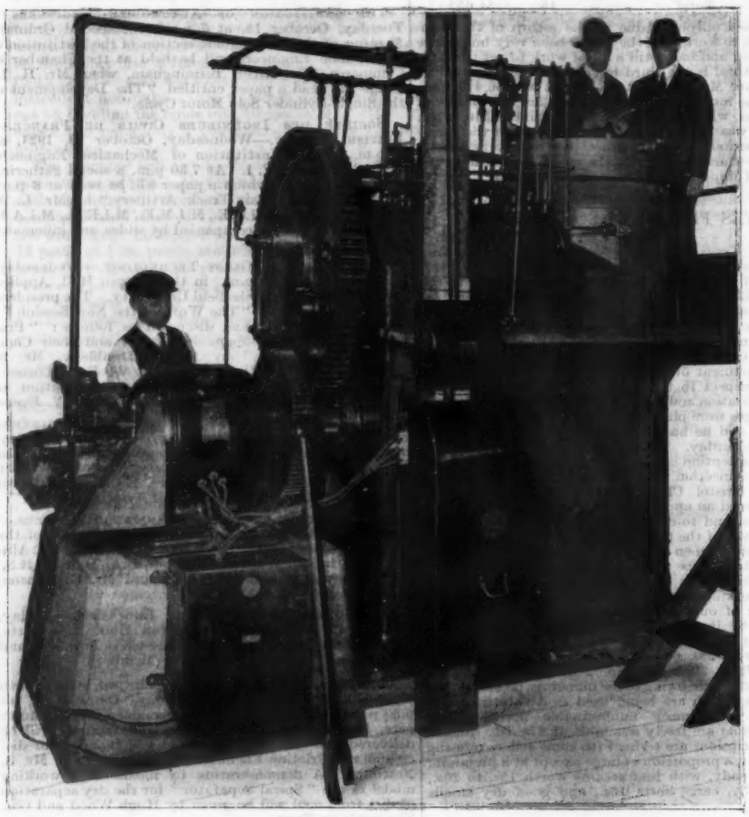


Fig. 3. General View of the Machine.

Fig. 4. Ram End of Machine and Indexing Gear.

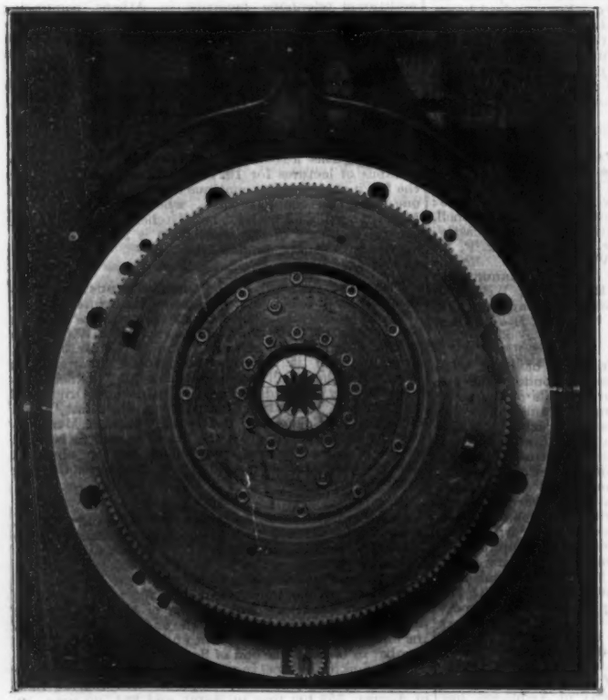


Fig. 5. The Underside of the Tool Head.

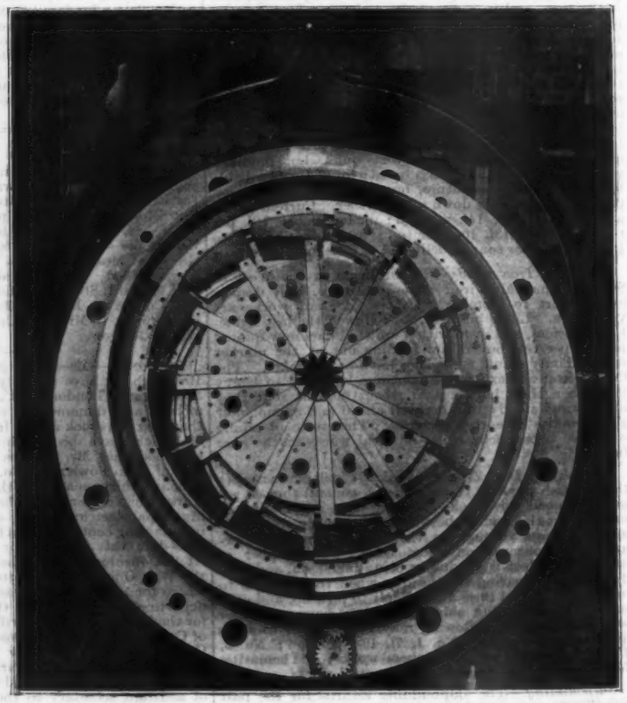


Fig. 6. Tool Head partly Dissembled.

6,500 CUBIC FEET AIR COMPRESSOR FOR THE NEW MODDERFONTEIN GOLD MINE.

CONSTRUCTED BY MESSRS. BELLISS AND MORCOM, LIMITED, ENGINEERS, BIRMINGHAM.

(*For Description, see Page 535.*)

Fig. 2.

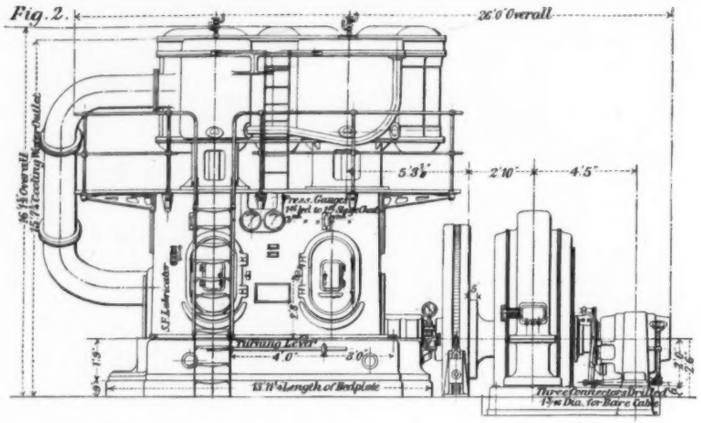


Fig. 3.

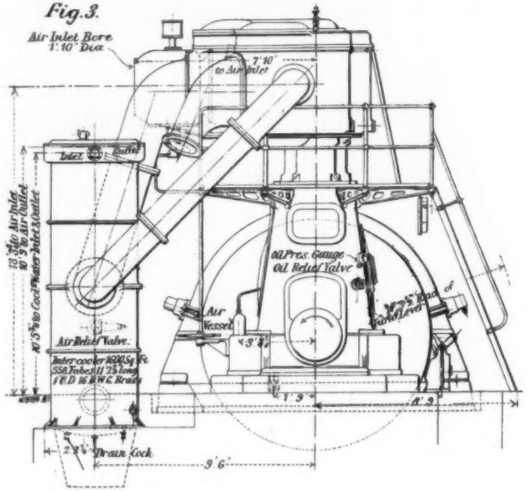


Fig. C.

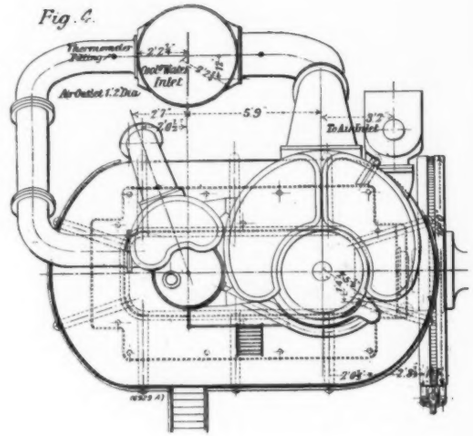


Fig. 5.

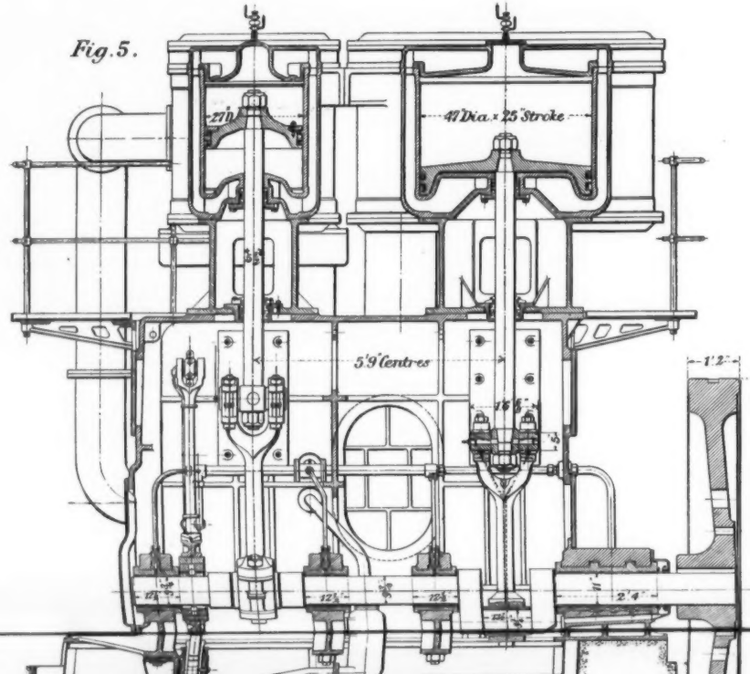
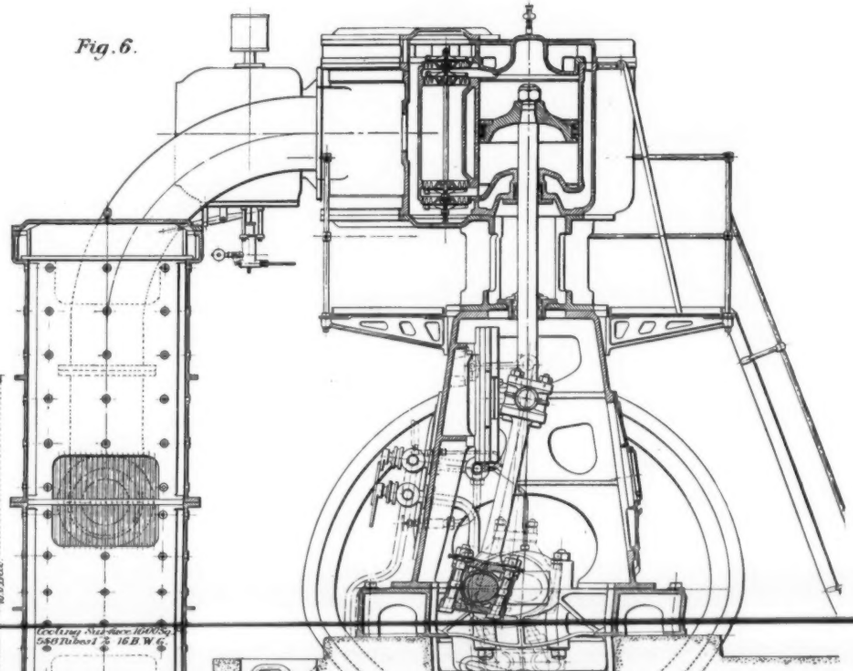


Fig. 6.



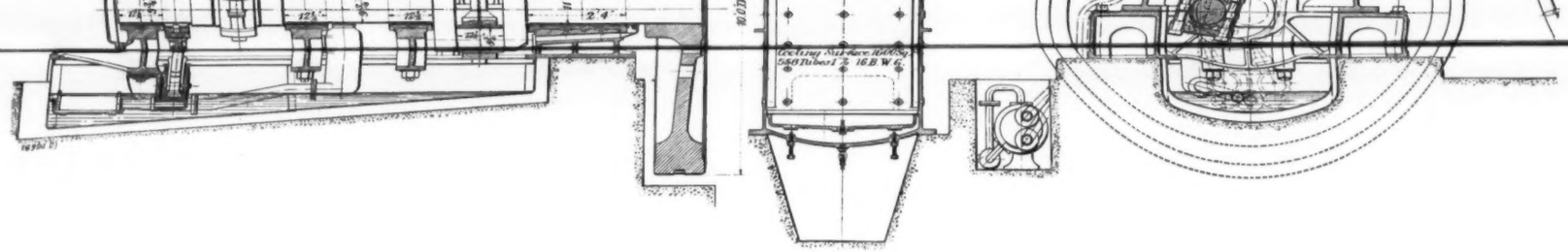


Fig. 7.

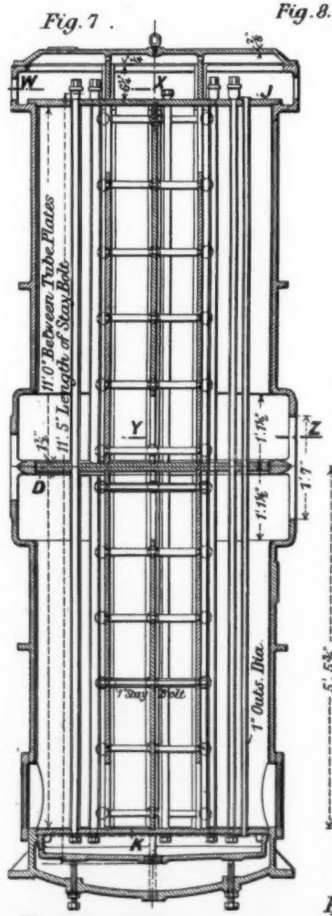


Fig. 8.

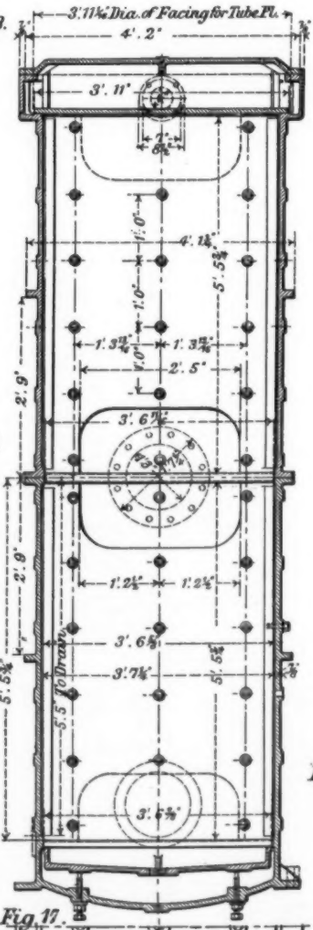


Fig. 9

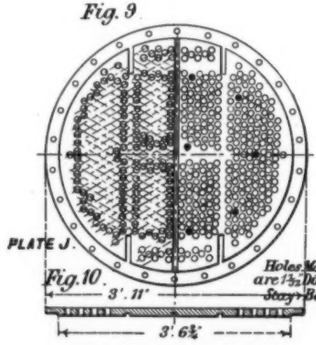


Fig. 10.

Fig. 11.

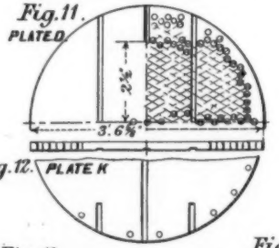


Fig. 12. PLATE K

Fig. 13. HALF PLAN LOOKING ON TOP COVER.

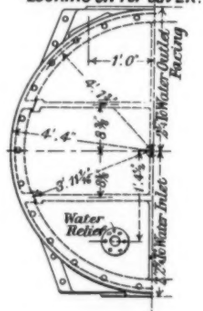


Fig. 14. HALF SEC. ON W.X.

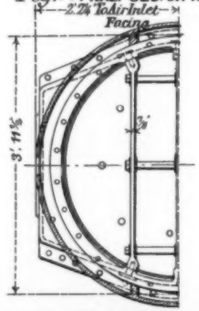


Fig. 15. HALF SEC. ON Y. Z.

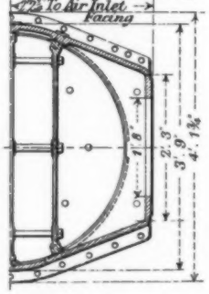


Fig. 16. STAYBOLT.

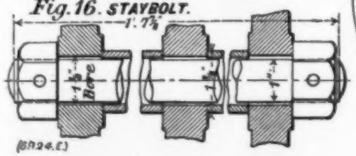


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Fig. 17.

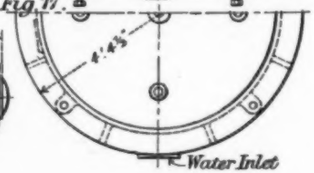


Fig. 18.

Fig. 19.

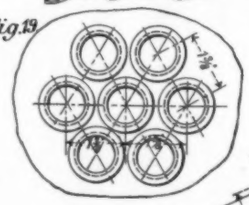


Fig. 20.

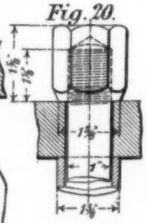


Fig. 21.

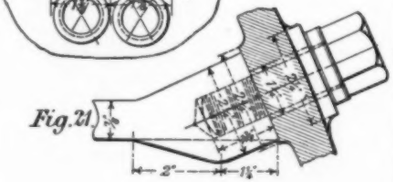


Fig. 22.
FULL LOAD.
1ST STAGE
Pressure Scale 1" = 60 Lbs. per Sq. In.

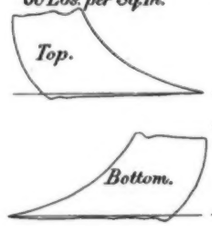
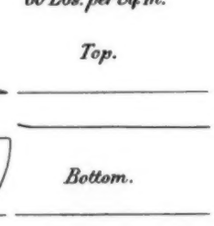
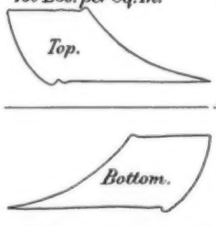


Fig. 23.
NO LOAD.
1ST STAGE
Pressure Scale 1" = 60 Lbs. per Sq. In.



2ND STAGE
Pressure Scale 1" = 160 Lbs. per Sq. In.



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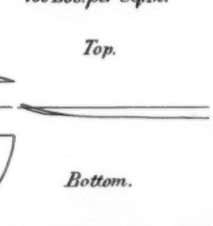

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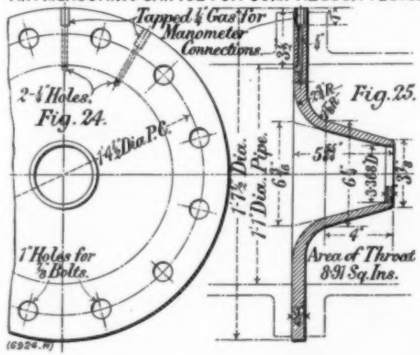
AIR MEASURING ORIFICE FOR COMPRESSOR TESTS.



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The charge for advertisements classified under the Headings of Appointments Open, Situations Wanted, Tenders, &c., is four shillings for the first four lines or under, and one shilling per line up to one inch. The line averages seven words. When an advertisement measures an inch or more the charge is 12s. per inch. Payment must accompany all orders for single advertisements, otherwise their insertion cannot be guaranteed. Terms for displayed advertisements on the wrapper and on the inside pages may be obtained on application. The pages are 12 in. deep and 9 in. wide, divisible into four columns of 2¼ in. in width. Serial advertisements will be inserted with all practicable regularity, but absolute regularity cannot be guaranteed.

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NOTICES OF MEETINGS.

Notices of Meetings to take place during the present and next week will be found on page 541.

ENGINEERING.

FRIDAY, OCTOBER 14, 1921.

ENGINEERING INSPECTION.

IN repetition manufacture it is necessary to arrange some department of the works in which parts after completion, or may be before completion, shall be inspected or gauged to ascertain if they fall within predetermined limits of size and reach a postulated quality of finish. The engineering knowledge demanded from the inspector in work of this kind is not usually high, and the work is frequently carried out by girls. This kind of inspection increased enormously during the war and, as is common knowledge, was almost entirely in the hands of non-technical workpeople, only too frequently directed by non-technical, or amateur, heads. When the work of an inspector is confined to ascertaining if a part lies within easily-gauged limits, or if, in special cases, such as balls for bearings, it does, or does not, contain flaws or cracks, then the work may certainly be carried out equally well by a girl as by a fitter.

The actual cases, however, in which a part must be either right or wrong are comparatively few. The case of ball bearings which we have quoted is such an one. If a ball has a small crack in it, or a soft place, then it is useless and must be scrapped. The matter is not open to argument. This is proper work for non-technical labour. In the majority of cases, however, there is room for individual judgment. A part may fall within all gauge limits, but may, for instance, carry a small surface defect or may be roughly machined in a fillet, and it at once becomes a matter of opinion if it should, or should not, be passed as correct. As a matter of practical expediency most repetition gauging of this kind is carried out by unskilled labour and any doubtful cases, such as we have instanced, are referred to the foreman or, eventually, to the manager of the department. As work becomes more complicated the reference to higher authority must become more frequent, and a stage is reached in which the work cannot commercially be carried out by unskilled labour at all.

It is not always remembered that inspection is not introduced to catch out workpeople and subcontractors on minor points. It is undertaken to ascertain if a part, or a machine, is up to a certain standard of quality and accuracy of dimensions and is suitable for the duty for which it is intended. In all but the simplest cases it involves matters of judgment, and consequently should either be carried out directly by a highly-skilled man, or under his immediate supervision. When inspection is concerned with complicated machines, or expensive materials, it becomes of necessity a highly-skilled job requiring much experience and judgment, and quite apart from the manufacturer it will usually pay the purchaser to have a skilled inspection made from the point of view of his interests. The necessity for work of this kind has given rise to a special branch of the engineering profession.

Although inspection carried out by an independent firm is a well-known feature of modern engineering practice, it is doubtful if the employment of such inspection is anything like as widespread as it well might be. Locomotive builders are familiar with the inspecting engineer whose duty it is to see that his client gets an article generally to specification and that will do its job without trouble, but there are very many engineering manufacturers who have little experience of him, while it is certain that very large amounts of engineering material are bought without inspection of any kind. It is quite probable that many people, and notably many purchasing agents, have a notion that inspection of plant or material is not necessary if it is bought to specification. This is a most unsound idea. The most carefully drawn-up specification will be found to deal to a greater or less extent in general terms, and the interpretation of those terms in a manner fair to both parties is one of the first duties of a inspector. Further, no matter how rigidly it may be proposed to read a specification, points will always crop up requiring individual judgment, and the presence of a trusted and competent inspector who can come to some agreement with the manufacturers about such points is likely in the long run to save both money and temper.

The first qualification of an inspector is certainly technical knowledge of the type of material he is judging. If he does not know whether a minor surface defect is of importance or not, or if he does not know the quality of finish necessary for any particular class of work, then he simply cannot do his job. Next to this qualification, however, much discretion and an ability to work harmoniously with other people are important items in his equipment. The most brilliant technical man if he succeeds in antagonising the manufacturer whose work he is inspecting is quite likely ultimately to obtain a worse job for his clients than a man of more moderate technical accomplishments who introduces a little more subtlety into his relations with his associates. In many cases in perfectly good faith a manufacturer interprets such an expression as "the best quality of workmanship" in an entirely different sense from that which the purchaser gives to it, and it is one of the duties of the inspector to reconcile as far as may be these opposing attitudes.

It is indeed one of the first qualifications of an inspector that he shall know how such troublesome but probably necessary expressions as "best quality of workmanship," "good finish," &c., should be interpreted. They mean very different things to different people, and the "good finish" of the domestic mangle maker is quite a different thing from the "good finish" of the milling machine builder. An experienced inspector will frequently have a good idea beforehand of the class of finish and workmanship to expect in the products of any firm which he is visiting for the first time, and in any case a very short experience will enable him to judge the quality and finish of work he is likely to get. A large proportion of contracts are naturally placed with firms whose type of work is well known to the purchasers, but none the less very many are entrusted to little known firms. In these latter cases the services of an inspecting firm are likely to prove very valuable. This is particularly the case when contracts are placed abroad.

Some valuable remarks on the inspection of material and plant ordered abroad, particularly with reference to the Continent, were made in an able and interesting paper on "Independent Inspection in Engineering," by Mr. H. J. Davey and Mr. H. Gutteridge, which was read at the recent engineering exhibition at Olympia. An excellent instance of the value, indeed the necessity, of good inspection was given by Messrs. Davey and Gutteridge in their reference to large sub-contracting work in which a number of different firms are concerned. Anything approaching a unity of quality and proper fit and correspondence between work done in different shops, and even in different countries, can only be obtained by careful and continuous inspection, and it will be fairly obvious that such work can best be done by a specialist inspecting firm. The work must be watched practically throughout, and odd visits by a representative of the purchasing firm to see how things are getting on will do but little to ensure any unity of quality or fit between parts made in different places.

The difficulties are accentuated when part of the work is being carried out abroad. It is quite possible that drawings prepared in English measure may be converted into metric equivalents by the subcontractor before he releases them to his shops. This will almost inevitably result in minor inaccuracies which a competent inspector will always have in mind. Different methods of production, different ideas of what constitutes accuracy and many other qualifying factors have also to be watched. It is not necessarily suggested that work turned out on the Continent will be inferior to that produced at home. The point of importance, and that which it is the duty of the inspector to insure, is that there shall be fair uniformity throughout the

whole of the finally completed job and that the various parts shall fit together properly. Such effects as these can only be achieved by continuous inspection. We have much sympathy with Messrs. Davey and Gutteridge's contention that for buyers in this country the work is best placed in the hands of a qualified British inspecting firm. Integrity and technical skill are ensured in this way, and with a better knowledge of the class of work the purchaser is likely to desire and expect.

The authors raise the question of the inspection of engineering material particularly from the point of view of the peculiar situation of the moment. They point out that we are faced with the almost complete stoppage of production from blast furnaces in Great Britain, and that very large quantities of foreign billets have been used for rolling into sections and shipbuilding material. They suggest that in these circumstances contracts calling for steel of British origin may possibly be filled with steel from quite other sources, and that purchasers who want what they are paying for are likely best to secure it by a system of continuous inspection. A further point they make is that at least 80 per cent. of the ingots produced in France, Belgium and Germany are of basic steel, and material purchased as Siemens-Martin is very likely to be basic unless inspection is made during manufacture. The quality of billets or other material supplied can also only be ensured by inspection, and the authors' quote a case of billets of such bad deformation that they could not be rolled. Redress in such cases is frequently almost hopeless, since the business may be done through two or more intermediaries, and a case has frequently to be fought in a foreign court. In spite of this, purchase without inspection is quite common and in the authors' words, it is difficult for the trained inspector to realise the "business" attitude of mind which will accept self-evidently, constantly recurring and avoidable risks of this kind.

MERCHANT SHIPBUILDING.

With British and foreign trade at its present low ebb little surprise will be felt that the present position and future prospects of the British merchant shipbuilding industry are far from bright. The number of vessels nominally under construction in British yards at the end of September last, according to returns just issued by Lloyd's Register, was certainly very considerable, being 700 with a total gross tonnage of 3,282,972, although the latter figure is about 247,000 tons less than that for the end of the June quarter and 448,000 tons less than the tonnage in hand a year ago. Work has, however, been suspended on 731,000 tons of shipping included in the above-mentioned figure for tonnage under construction at the end of last month, and the completion of a further 457,000 tons has been postponed owing to abnormal causes. The tonnage on which work is actually proceeding at the present time thus only amounts to 2,095,000 tons, which is only 56 per cent. of the tonnage in hand a year ago.

Even more significant with regard to future prospects are the figures for the tonnage commenced during the September quarter, which amounted to only 51,343 (19 vessels), as compared with 23 vessels and 69,028 tons commenced during the preceding quarter and 170 vessels making 593,821 tons commenced during the quarter ended September, 1920. A reduction has also occurred in the number and tonnage of vessels launched, the figures for the September and June quarters of this year and for the September quarter of last year being 92 vessels (307,850 tons), 100 vessels (321,690 tons) and 144 vessels (483,057 tons), respectively. The reduction in the proportion of tonnage completed during the quarter to the tonnage in hand at the commencement of the quarter, which was referred to in an article on page 108 *ante* dealing with the figures for the June quarter, is still more marked, the average figure for the first three quarters of this year being only 8½ per cent. The corresponding figure for 1920 was 13 per cent. and for 1913, the last complete year prior to the war, the figure was 23 per cent.

Of the vessels now classed as "under construction," 630, with an aggregate gross tonnage of 3,047,964, are steel steamers, and there are three other steamers of wood and composite construction, making 1,912 tons together. The motor vessels building number 50, and have an aggregate gross tonnage of 229,325, while 17 sailing ships, making only 3,771 tons in all, complete the total. These figures, it may be mentioned, include 81 steamers and motor vessels with a total gross tonnage of 527,791 intended for the transport of oil in bulk. The majority of the vessels now building are each, of course, of less than 10,000 gross tons, but 62 steamers of higher tonnage are in hand. Of these seven are between 10,000 and 12,000 tons, 25 between 12,000 and 15,000 tons, 24 between 15,000 and 20,000 tons, five between 20,000 and 25,000 tons, and one between 25,000 and 30,000 tons. The largest motor ships now in hand are of less than 10,000 tons and more than 8,000 tons, eight vessels coming within that range, while 16 vessels come within the range 6,000–8,000 tons, and four are between 5,000 and 6,000 tons. Of the vessels of all types now building, 214, with a total tonnage of 992,869, are intended for the British Dominions or for foreign owners, our most important foreign clients being France, Holland and Norway. For these three countries we are building 223,181 tons (41 vessels), 211,914 tons (25 vessels), and 112,814 tons (35 vessels), respectively.

As might be expected from the figures given above, the work in hand in all the important shipbuilding centres of the country has declined during the quarter. Glasgow is now building 176 vessels, with an aggregate tonnage of 923,926, as compared with 184 vessels, making 953,798 tons at the end of June, the reduction in tonnage amounting to just over 3 per cent. At the other Clyde port of Greenock, the reduction is rather less and amounts to about 2½ per cent., the figures for June and September being 292,530 tons (54 ships) and 285,236 tons (52 ships), respectively. On the Tyne the decline in shipbuilding work has been considerably greater, the Newcastle district having now only 102 ships, making 603,194 tons in hand, as compared with 118 ships, making 680,334 tons, which were building there three months ago; in this district the reduction in tonnage building is well over 11 per cent. Belfast has suffered least of the important shipbuilding centres, the work there having declined by less than 2 per cent. from 356,150 tons (42 ships) at the end of June to 349,600 tons (40 ships) at the present time, but at Sunderland the percentage reduction in shipbuilding work is practically the same as that at Newcastle. The vessels building at Sunderland now number 59 and have a total gross tonnage of 291,276 as compared with 65 vessels, making 328,488 tons together, which were building there at the end of June. Work at Middlesbrough has also declined to the extent of 10·9 per cent. during the quarter, the tonnage figures for June and September being 213,258 and 190,018, respectively. The only other districts with more than 100,000 tons of shipbuilding work in hand are Liverpool and Barrow, the figures for these ports being 115,655 tons and 101,460 tons at the end of last month. The reduction in work at Liverpool during the quarter amounts to nearly 3 per cent. while the corresponding figure for Barrow is over 6 per cent. At Hartlepool the tonnage building at the present time amounts to 89,880, which is practically the same as that in hand at the end of June, but the present figure for Hull (viz., 60,523 tons) is about 11½ per cent. lower than that for June. The work is hand at other centres in order of magnitude is as follows:—Dundee, 70,100 tons; Southampton, 58,554 tons; Leith, 28,653 tons; Newport, Mon., 18,546 tons; Londonderry, 17,800 tons; Aberdeen, 15,420 tons; and Dublin, 11,840 tons.

The suspension of work, which has been a regrettable feature of the British shipbuilding industry for some time past, has now appeared in foreign yards, Italy and the United States being the countries mainly affected. Of the merchant tonnage now classed as under construction abroad, the total amount of which is 2,260,006 tons comprised in 775 vessels, work has been suspended on about 375,000 tons or, say, 16·6 per cent. The drop in the total figure during the quarter has amounted to 409,000 tons, and is mainly accounted for by the continued reduction in shipbuilding in the United States, which country is now building only about 10·5 per cent. of the tonnage in hand at the end of the first quarter of 1919. The vessels now under construction in the United States comprise 60 steamers with a total tonnage of 419,667, three motor vessels making 5,895 tons together, and six sailing ships with an aggregate tonnage of 8,400.

Italy stands next in order to the United States as regards work in hand, with 397,544 tons, but as the two countries together have only rather more than 800,000 tons building, and their suspended tonnage represents a good part of the foreign total of 375,000 of delayed tonnage, it is clear that the industries are suffering like our own.

It is not to be expected that with the practical cessation of manufacturing and trade in the world shipbuilding could be otherwise than depressed. Conditions at present require small freightage, and as shipping exists merely for the transport of freight it naturally follows that without freights the ships are useless, and in these circumstances new ships will certainly not be laid down, unless for special services. Recently there has been under discussion the question of the 12½ per cent. war bonus which has been in force in the shipbuilding and engineering trades, and a ballot is being taken this week on the demand by the employers that this should be discontinued. It may be pointed out that, while in the shipbuilding industry the cessation of the bonus would enable rather more attractive offers than are possible at present to be made by the builders, there is little prospect of the industry reviving until signs may be seen of a general revival of trade. If confidence could be restored between nations and individuals, renewed trading would become possible, ships would be wanted and new ones would be built. Though it would be hardly logical to abolish one without the other, for the moment the question of the engineers' bonus is actually of greater importance than the shipbuilders, the engineers having the more direct influence on the revival of export trade which, re-established, would put shipbuilding on its feet again. More vital, however, than the question of any bonus is the revival of that spirit of industry which prompts a man to good effort. Having put this into the work, and with confidence between peoples, we shall find it feasible to attract and develop trade in a way which is quite impossible when wages are only regarded as related to the cost of living, instead of to the proper basis of what a sound industry can carry.

NOTES.

Public Transport.

Not the least of the services which the Institute of Transport may render is the consolidation of the idea that the future of transport in this country is one problem and not many. The railway man naturally must pay most attention to his own difficulties and the development of his own schemes, but the more he realises that his activities are linked with road transport, shipping and even air travel, then the better and more ultimately valuable is his work likely to be. The same thing applies to the other branches of transport. This conception of the interdependence of the various classes of work was well in evidence at the second annual dinner of the Institute which was held at the Hotel Cecil on Monday last and is reflected in the list of speakers which included Lord Ashfield—the president—and Sir Henry Thornton representing railways, Sir Henry Maybury and Mr. Shrapnel-Smith representing road transport, and Major-General Sir F. H. Sykes representing air travel. The tone of many of the speeches emphasised this essential unity of all modes of transport, but many could not but dwell on the poverty and unrest which are hampering developments of all kind throughout the world. A sufficient indication of the conditions which have to be forced was given by Lord Ashfield when he stated his opinion that the gross receipts of the railways of the country this year would be insufficient to pay working expenses. A condition such as this, which unfortunately is not confined to railways, hardly appears one in which profit lies in the discussion of grandiose capital expenditures and for this reason, as well as others,

we are not impressed with Lord Ashfield's proposals for underground roads. Lord Ashfield, of course, knows as well as anyone else that railways won't get any more money to build anything until they can earn some profit on the money they have already got, and the cultivation of a unity of interest among all modes of transport may perhaps do something to help this consummation. If the Institute of Transport by example, or precept, can help railways, or any other bodies, to earn dividends they will be performing what is the best possible work. Sir Henry Thornton appeared to us to show the most practical grasp of present conditions.

IMPENDING CHANGES IN THE LAW OF CARRIAGE.

It may not be generally realised that the Railways Act, 1921, contains provisions which will sooner or later modify the Carriers Act, 1830, in certain important particulars. As from "the appointed day"—which is to be fixed by a Rates Tribunal set up by the Act—the Carriers Act "in its application to railway companies," is to be altered. Another proposed alteration in the Act as it affects railways is to be noted. Hitherto it has only applied to carriers by land. It has no application to those who carry by sea. Consequently, a railway company owning a line of steamers has not been bound by the Carriers Act in so far as the sea part of a journey is concerned. After "the appointed day," however, all the provisions of the Carriers Act in their application to railways are to apply as if "Carrier" included a common carrier by land who is also a carrier by water. A curious and perplexing feature of these proposed alterations in the law is that they will have no application to an ordinary carrier, *i.e.*, a common carrier who carries by road, whether in motors or other vehicles. In so far, therefore, as heavier liabilities are placed upon railway companies by the amendment of the Carriers Act, added impetus will be given to the competition of other carriers who merely have to bear the burden imposed by the old Act. Prior to that Act, the common carrier was an insurer of all goods conveyed by him. He was liable for all damage and all loss unless occasioned by the Act of God, the King's enemies, or "inherent vice in the article carried." He could only avoid this liability by insisting upon the consignor entering into a special contract. The burden thus placed upon carriers having been thought too heavy, it was provided by the Carriers Act that the carrier should not be responsible for the loss of, or injury to, certain articles exceeding 10*l.* in value contained in a parcel or package unless the nature and value of the article was declared by the consignor. A list of these articles was inserted in the Act. Generally speaking, they are articles of small compass and great value, *e.g.*, money, jewellery, deeds, documents, silks, &c. Until the present year this list has never been altered or added to. By the Act of 1921, the list is to be modified by striking out "silks"; but a further and more important amendment is made. The minimum of 10*l.* is raised to 25*l.* Consequently, every railway company will, after the appointed day, become an insurer of all articles of which he is a common carrier provided the value of that article is less than 25*l.*

THE MANCHESTER ASSOCIATION OF ENGINEERS.

The Manchester Association of Engineers opened its session on Friday, October 7, when an address was delivered by the President, Mr. F. J. West, C.B.E. The fact that this Association has changed its day of meeting is, perhaps, not a point to lay much stress on, but it is indicative of the changed times and of endeavour to readjust life to conditions different from those existing when the Association was formed. Originally, meeting on Saturday the Association was intended to meet the needs of those who in a busy week were most likely to be free to attend after the Saturday half-day. Now presumably the common wish to have the week-end free for purposes other than those connected with the weekly round, and possibly also the widening of the circle to whom the Association appeals, has resulted in Saturday as a meeting day being abandoned in favour of Friday. We trust the change may prove conducive to an increase in the activities of the Association and an enhancement of the value of its work. As might have been expected, Mr. West's presidential address had a good deal to say on industrial matters, and advocated increased support of the Manchester Engineering Council formed in 1919, on the lines of the Industrial League and Council. Mr. West, on the experience of his two years' presidency of the Manchester Engineering Employers' Association, is strongly in favour of improving the relationship between the employers and employees by giving the latter better opportunities to understand the more intricate sides of a business which have such a bearing on its success or failure. As a means to this end, work committees and organisations such as the leagues and councils are useful. A note of warning is sounded in connection with committees, however, with regard to the duties of foremen. It happens that committees tend too frequently to question the action of the foreman, whose authority must, as Mr. West points out, be maintained if real efficiency is to result. Turning to another question altogether, Mr. West pointed to the anomaly of the engineer of a public body not being in a position to plead his own cause. A technical scheme may be planned, and approved by a sub-committee possibly with no engineering knowledge, and when the whole comes before the full borough or municipal council for decision, its only sponsors are probably non-technical councillors who formed the sub-committee. As a natural result the scheme suffers from ill-advised lopping ostensibly in the interests of economy. For this reason Mr. West urges the importance of greater representation on public bodies of the widespread influence of engineering and the technical aspects of modern life, and suggests that in the interests of the community more technical men should come forward for public work, and with this we heartily agree.

THE LOSS OF THE "R.38."

The report of the Court of Inquiry into the circumstances leading to the loss of the airship R.38, issued on Saturday last, adds but little information to that which could be gathered from the later and fuller accounts of the disaster published in the daily Press. The cause of the accident, in the opinion of the court, was that the structure failed in the rear of the after engine cars, and the hull broke in two while the ship was being subjected to rudder and elevator tests at a speed of about 45 knots to 50 knots. It appears that almost extreme helm, with quick reversal, was being used at the time, and the swing of the stern resulting from this manœuvre set up greater stresses in the hull framing than could be resisted. The heavy loss of life was mainly due to the fire which broke out in the forward portion immediately after the fracture, and probably originated in a spark resulting from the parting of the electric leads igniting the petrol escaping from broken mains. The explosions which occurred subsequently and the ignition of the hydrogen are, of course, not difficult to account for, and although but for these the number of survivors would have been much greater, it must not be forgotten that structural weakness was the real cause of the disaster. As mentioned in the article describing the airship, which appeared on page 723 of our last volume, the vessel was designed to meet requirements considerably in advance of those with which previous British airships had to comply, and the court points out that these requirements, together with the limitations imposed by the dimensions of the construction sheds available, necessitated the utmost economy in hull heights and materials. Numerous new features were incorporated in the design, and it now appears that vital aerodynamic data as to the effects of these modifications were lacking. Technical features, are however, not discussed in the report already issued. These, we presume, will be fully dealt with in the report of the investigations now in hand by the Aeronautical Research Committee. The Admiralty are also conducting a full investigation into the history of the design of the airship, and of the initial stages of its construction, for which they were responsible until October, 1919, when airship design and construction was transferred to the Air Ministry. Useful comment on the disaster is hardly possible until these two reports are available. It does, however, appear from the findings of the Court of Enquiry that the design of the airship was not examined and discussed by a committee of experts before construction was commenced; neither was this done after the armistice, by which time detailed information relating to airships built elsewhere had become available. The R.38 was not therefore, as might have been expected, the embodiment of the skill and experience of British airship designers as a whole, but whether or not the combined knowledge of these men would have sufficed to detect the weakness in the early stages of the design can only be surmised from the information so far made public. What might have prevented the disaster, however, appears to us to have been a very careful examination of the design after one of the preliminary trials in which the weakness of some of the girders amidships became evident. These particular girders were certainly re-inforced before the final trial, but their weakness was evidence that some of the assumptions made in the design were inaccurate. Doubtless this point will be dealt with in the reports of the investigations now proceeding, and until these are issued judgment must be suspended.

PEAT CARBONISATION IN VERTICAL GAS RETORTS.

Very promising results have been obtained by the Fuel Research Board in experiments on the carbonisation of machine-won peat from the bog of Turraun. The peat had been macerated in 1920, and spread and air dried on the bog; a hundred ton of this peat arrived in East Greenwich early in 1921. The blocks, 10 in. long, 2 in. square, had a density of nearly 1, and were sufficiently hard to be sawn and cut like wood; they had stood the transport well, giving only little smalls, whilst the hand-cut sods, of half the density, crumbled badly in transport. The blocks contained still 25 per cent. of moisture which decreased to 17 per cent. on storing the peat under cover. The disintegration of this peat in crushers yielded a good deal of dust, and the roots and twigs proved troublesome. An attempt was therefore made to break the blocks up by hand; that was unsatisfactory, however, and the crushers had to be used, though it meant that the stokers had to poke the sticks in the peat through the small coal valve into the feed hopper of the retort, so that they were, for 5 minutes out of 20, exposed to the very unpleasant fumes rushing from the top of the retort. This difficulty could easily be obviated on a special plant. But the dust difficulty would remain, unless the dust were especially separated from the peat fragments, which has not been done so far; the dust is carried over into the gas main, forming a thick mass with the tar, which once choked the main. The volume of gas was so great that a positive pressure in the retort and main was hardly to be avoided. The carbonisation was first carried out at 1,000 deg. C. in four retorts, in a second series of runs, at 880 deg. to 830 deg. C. in two retorts; the operations were regulated so as to secure a through-put of 3 tons per retort per day. The carbonisation required 3,480 cub. ft. of peat gas per hour. In addition to this gas the ton of peat yielded 26 therms (7,940 cub. ft.) of gas of 325 B.Th.U., 12·6 gallons of tar, 95·5 gallons of liquor of 3·6 ounces strength, and 5·4 cwt. of charcoal, which last named proved an ideal fuel for suction-gas producers, though it contained 10 per cent. of ashes. We take these figures from Technical Paper No. 4 of the Fuel Research Board, obtainable from H.M. Stationery Office, Imperial House, Kingsway. The coke was quenched before its extraction by means of steam, 6 per cent. of steam by weight of peat being required for this purpose. The condensation of the tar and liquor called for special arrangements because the peat tar is lighter than coal tar. The vapours entered the condenser at 80 deg. C.; when they were cooled to 20 deg. C. (below the setting-point of the tar near 40 deg.) on leaving the condenser, the liquor issued as a yellow emulsion which had to be heated up again to about 50 deg. C. to secure a separation of the peat tar, as a black oily liquid, from the liquor. The dry tar made per ton of peat amounted to 12·6 gallons; it yielded some wax in fractionation and some spirit on distillation. The 95·5 gallons of liquor were relatively low in ammonia, yielding 29 lb. of

ammonium sulphate per ton of peat; the other chief products obtainable by distillation were methyl-alcohol and acetone. The peat gas contained 18 per cent. of carbon dioxide by volume and was hence very dense (density 0·768 air = 1) and difficult to clean in scrubbers; the gas also had a sickly odour. The contemplated continuation of the experiments certainly appears to be justified.

THE INSTITUTION OF GAS ENGINEERS.

The annual general meeting of the Institution of Gas Engineers was held on the Tuesday, Wednesday and Thursday of this week. The first two days were devoted to the discussion of reports, in the Central Hall, Westminster; on the third day visits were paid to the South Metropolitan Gas Works at East Greenwich, and to H.M. Fuel Research Station which adjoins these works. The meeting was originally arranged for the last week of May, but had to be postponed on account of the coal dispute, and most of the reports now discussed were drawn up for that meeting. Meanwhile the atmosphere of the gas industry—not of gas works—has become much clearer. The limitation of the proportions both of carbon monoxide and of incombustibles admissible in the gas supplied, then still under discussion by Committees of the Board of Trade, is no longer threatened. Thus legal uncertainties as to methods of gas manufacture have vanished, and efficiency may be studied almost without restrictions as to gas composition, whilst the question of means for securing a certain calorific value becomes more important than ever. These considerations naturally influenced the proceedings of the meetings. The agenda paper was more formidable than it appeared at first glance. The seven items set down for discussion on the morning and afternoon of the first day concerned long reports running, in one instance, into 84 pages, and, owing to the postponement of the meeting, the reports were not merely presented as printed. If the discussions strained the attention of members, the interest certainly did not flag; the hall was very well filled from ten till nearly six (with a break for luncheon), and the president, Mr. Thomas Goulden, M.Inst.C.E., had no need to encourage speakers. The excellent work of the Research Committee found warm general appreciation, but did not escape appropriate criticism.

Presidential Address.

In the course of his address Mr. Thomas Goulden mentioned that in the period 1909 to 1919 the annual consumption of gas had increased from 177,687,000,000 cub. ft. to 228,538,000,000 cub. ft., and the number of consumers from 6,167,066 to 7,540,133. In his own undertaking the consumption figures were 24,743,000,000 cub. ft. in 1909 and 31,964,000,000 in 1920, and the consumers had increased from 670,925 in 1909 to 843,128 in 1920; the number of consumers supplied by automatic meters had increased from 387,169 to 516,092, while the annual gas consumption per consumer had risen from 12,893 cub. ft. to 20,953 cub. ft. The total capital now invested in the gas undertakings of the United Kingdom was 150,000,000*l.*

As regards the calorific standard for the gas supplied, Sir Arthur Duckham had in 1918 suggested 450 B.Th.U. to 500 B.Th.U. In Massachusetts a minimum of 525 B.Th.U. had been recommended in 1917, with the reservation that this figure might require revision. Mr. Goulden himself regarded 500 B.Th.U. gross as undesirably high; he would prefer 475, which meant production of a gas of 485 B.Th.U., as being economical in manufacture and distribution. With respect to water gas he stated that his own company made last year 35,148,709,000 cub. ft. of gas, of which 20·9 per cent. was water gas, mostly lightly carburetted; to prepare this 147,700 tons of coke had been used. If no water gas had been made, the coal consumption of that year, 2,279,250 tons, would have had to be supplemented by 415,750 tons, and that quantity of coal had been saved to the country by the manufacture of water gas at the expenditure of 355,000 tons of coke, representing that which would have been residual from the additional coal, plus that consumed in water-gas manufacture. We remember that similar figures (probably the same) were given before the Carbon Monoxide Committee, and the precise meaning of the term "saved" was not considered quite clear by the Commissioners.

Commenting upon Labour and Co-partnership, Mr. Goulden spoke of a struggle of a severe order likely to extend over an indefinite, but lengthy period, and referred to the coal-mining dispute as a disaster of the first magnitude to the country. He advocated closer human relations with the workpeople, better personal knowledge and more sympathy between labour and employers than usually existed. Co-partnership, introduced into the gas industry by the late Sir G. Livesey, had not been commenced in the Gas Light and Coke Company until several years subsequent to the inception of the South Metropolitan scheme; but he could testify from personal observation to the mutual benefit resulting from it; upwards of 300,000*l.* of the company's stock was now held by their employees. His experience of works' committees was equally happy. At all their stations the representatives of the workmen met the superintending staff periodically to consider "domestic" matters, suggestions from workmen were encouraged, and the National Joint Industrial Council for the Gas Industry, in conjunction with representatives of the Institution and of the Board of Education, were interesting themselves in the education of gas workers. The gas engineer, Mr. Goulden proceeded, should be an engineer in the true sense, and not merely a superintendent of gas works. Engineering knowledge was now much more indispensable than before the war. The pity was that the remuneration of many responsible engineers was so poor that the need for the creation of an Association of Technical Gas Officials had arisen. Gas engineering should attract well-educated men; but without adequate financial recognition the right stamp of men would not be secured.

Mr. Harry E. Jones, a past-president of the Institution, proposed the vote of thanks to Mr. Goulden, which was seconded by Mr. D. Milne Watson, M.A., governor of the Gas Light and Coke Company.

The president then presented Mr. Samuel Glover, M.Inst.C.E., his predecessor in the chair, with a congratulatory address on the attainment of fifty years' service in the St. Helen's gas undertaking, from which he is now retiring. Mr. Glover had, during the war, stepped aside to let the presidency pass to the late Lord Moulton; members rose to honour Lord Moulton's memory.

Recording Gas Calorimeters.

The report on "Recording Gas Calorimeters" was the first report of the Research Committee of the Institution which was brought up for discussion. Professor A. Smithells, F.R.S., is chairman, and Professor J. W. Cobb, F.I.C., of Leeds, honorary secretary of this committee.

In presenting his report, Professor Cobb said that the accurate measurement of thermal units demanded two determinations, one of volume, the other of calorific value. One of the principles they had insisted upon during the discussions of the last year had been that unsatisfactory performance with gas-fired appliances was far more likely to arise from fluctuations in the quality of a gas supply than from any defect inherent in gas of a particular quality or calorific value. Nothing could be said in favour of departing more from the declared calorific value than could be avoided. Working below that value should involve a penalty, whilst the gas engineer was not likely to throw heat units and money away by working above it. The amounts involved were rather startling. Taking the price of the therm at 10*d.*, and assuming that all the gas works of the country were working at 1 per cent. above the declared calorific value, the loss incurred by the delivery of therms without payment would amount to about 400,000*l.* per annum.

The Calorimeter Sub-Committee of the Institution had hence co-operated with the Gas Research Committee in thoroughly examining an instrument which could be regarded as representative of best design and workmanship. They had selected the Simmance total heat recorder, to which Sir George Beilby and the Fuel Research Board had already given a blessing; 74 out of 84 pages of the report, we may add, dealt with the Simmance recorder. The general impression to be carried away from a perusal of their report, Professor Cobb continued, would be that the possibilities of error were so numerous and their elimination was so difficult, that the design and construction of the perfect calorimeter would be a very difficult matter. Mr. Simmance was highly to be congratulated on the degree of success he had attained. In many respects his instrument was excellent, especially with skilled attention. Under favourable conditions the recorder might also give reliable continuous records with but little attention over considerable periods. But if the demand were made that the calorimeter should give a record sufficiently reliable for official and penal purposes under all the conditions in use, they found that the Simmance instrument could not meet that demand. They had attempted to determine the limits of reliability. They had also examined the well-known Beasley instrument, which worked on an entirely different principle—it might be called a differential thermometer—and was not a water-flow calorimeter like the Simmance. Although for various reasons unsuitable for official and penal purposes, the Beasley calorimeter seemed very useful for works control and was simple to operate and maintain. One criticism made of this instrument, that it recorded net and not gross calorific value, had very little force. That feature would not, under ordinary conditions, introduce any difficulty in using the Beasley instrument for maintaining a constant calorific value or for treating deviations therefrom.

In conclusion, Professor Cobb expressed the deep indebtedness of the committee to Mr. James Wood, M.Sc., their research chemist, and to his assistant, Mr. G. B. Howarth, B.Sc., for the ingenuity and perseverance with which they had carried out the investigation, and, further, to the Birmingham Gas Corporation department and their chief chemist, Mr. T. F. E. Rhead, M.Sc., for the provision of laboratory facilities.

Mr. J. Wood then gave particulars of the investigation. The governor, he stated, automatically compensated satisfactorily—within certain limits—for changes in the density of the gas and in atmospheric temperature and pressure. They had at Birmingham facilities for changing these features in the gas supplied, and for experimenting with gas, air and hydrogen. The range over which governing was found satisfactory depended upon the density of the gas. As long as the density of the gas kept near 8·5 the control was satisfactory; for higher and for lower densities fluctuations occurred, while in some cases gases of equal density might be delivered at different rates. Control of the room temperature (near 60 deg. F.) was desirable. The water-rate tended to slow down and could not be depended upon for more than a day or two, so that the instrument could not long be left unattended. The chemical and physical purity of the water and steady supply conditions were one of the main difficulties, especially with intermittent changes. No trouble had been caused by air-locking. The temperature of the inlet and outlet water was important. These difficulties had partly been met by recent improvements in the instrument, but the influences were not quite eliminated, and records might become unreliable at the end of a week and would almost certainly become useless at the end of a month. Those troubles would be small, however, for gas of density 0·40 or 0·45.

Mr. Goulden, in calling upon Mr. Simmance, remarked that we were not yet within reach of a perfect recording calorimeter. Mr. Simmance stated that he welcomed the report. He could not say anything that would not be complimentary to the committee; yet they were perhaps a little hard on him in some points. His governor worked at a very low pressure—that is to say, it was actually doing mechanical work at a pressure of 0·02 in. He did not think that pressures of 0·01 in. were correctly recorded in many laboratories. Some of the criticisms sounded rather like history—a light motor car with a heavy load for which it was not built. He had devised his calorimeter in 1916 and it had been tested at Birmingham as sent by him. He had himself watched it under gas-gravity changes made every half-hour between 0·4 and 0·67, and

the governor had behaved very well. The unsteadiness of the water flow was the chief difficulty; but the influences were slight. He was doubtful whether the Gas Act did not demand something that was beyond our reach. He would be delighted to hear that a perfect recording calorimeter had been brought out; it would have to be something quite new.

A speaker, whose name was not given, commented further on the difficulties of the water supply; some meters were blocked up by sediments, and to obviate such troubles it might be best to use distilled water.

Mr. A. Blackie, M.A., of the Fuel Research Station, said that they had not been able to conduct so complete an investigation, and his observations of the most recent type of Simmance recorder were not yet sufficiently advanced. On the whole, he agreed with the report, perhaps not finding the influence of the gas density so marked. He had noticed some clogging of the calorimeter burner, however, though that feature had also been improved. The control of the room temperature seemed less important than the prevention of heat loss or gain through the walls of the calorimeter; very careful jacketing of the instrument was required. As regards the water, they were rather unfortunate at Greenwich. Their water contained carbon dioxide, and a big bubble of gas going off suddenly would upset the meter rate. The change of the viscosity of the water with temperature had also to be considered.

Mr. Fairweather then briefly described the calorimeter designed by the late Professor Fairweather. His chief point was the automatic regulation of the water supply by means of the change of volume of an air-oil chamber. No arrangements having been made in the hall for the display of lantern slides, the description of the instrument was difficult to follow. He mentioned that the calorimeter was of the Boyd pattern; the gas was cooled before entering the meter, and an accuracy of half per cent. was obtainable.

The chairman announced that the calorimeters referred to, as well as that of Dr. Thomas, who was not present, could be examined in the London County Council Testing Station, Carlyle Square, Chelsea, during the course of the meeting.

Dr. J. G. Stewart put the question whether the intention of using standard calorimeters in ordinary practice was not wrong. Electricians did not use standard instruments for their meters. Dr. W. W. B. Davidson submitted that it did not seem rational to reduce the therms observed to 60 deg. F., whilst observations were made at 45 or 48 deg. F., which would make a difference of several per cent.

Professor Smithells contented himself with a few complimentary remarks, and Mr. Goulden, in closing the discussion, said that the difficulties of the calorimeter were very great, but they might rely on their research committees and the thorough care of the gas referees. One cannot help feeling that the adoption of the therm as a commercial basis was perhaps a little premature. The electricity meter would not have gained its footing so quickly if electric measurements had not admitted of greater accuracy than the measurements which the recording calorimeter requires, and even the electricity meter is as yet by no means infallible.

Blue Water-Gas.

In presenting this report, the sixth of the Gas Investigation Committee, Professor Cobb remarked that, reporting last year upon the steaming of Glover-West continuous vertical gas retorts at Uddingston, which might in one sense be regarded as the making of water-gas inside the retort, they had announced that they were going to investigate the supplementary problem of the manufacture of blue water-gas in an outside generator. In this work, again, they were indebted to the Birmingham Corporation Gas Department and to Messrs. A. W. Smith, the manager, J. Forster, chief engineer, and G. A. Bamber, who, as engineer of the Adderley-street works, was responsible for the actual control of the plant. The installation was of the well-known Humphreys and Glasgow make, working without waste heat boiler. The results could be accepted as representative of good water-gas practice under normal works condition and were, therefore not quite so good as might be expected under short-period test conditions. So far as possible the run and blow were divided up into short periods; the sampling then involved great difficulties, special methods had been devised, and by the aid of many analyses, measurements of weights, volumes, temperatures and pressures, the thermal and chemical balance sheets of the report (of 48 pages) had been drawn up. The three complete tests made gave substantially the same results. The efficiencies, as defined in the previous report by Sir Dugald Clerk, Professor Smithells and himself were found to be 46 per cent., when the fuel consumed by the steam generators and turbine was taken into account, and 56 per cent. when it was not. Those efficiencies were lower than could readily be obtained from a gas-producer plant; the difference was no doubt bound up with the fact that water-gas making was intermittent and the producer-gas process continuous. In this connection Professor Cobb reminded the meeting of the thermal advantages of continuous gasification in oxygen, to which he had drawn attention last year.

The biggest item in the heat loss was in the potential and sensible heat of the blow gas; this had suggested the advantage of a waste heat boiler, but the plant could not be altered beyond a certain point. The main value of the results was therefore in the information obtained as to the actual position of good modern practice, and the amounts of the heat losses, enabling, Professor Cobb hoped, engineers to experiment on improving their processes. The effects of shallower fuel beds were being investigated, and they were going to examine a carburetted water-gas plant, and, particularly, the performance of an attached waste-heat boiler. With the aid of their chemical balance sheets they were finding out what became of the carbon, sulphur and nitrogen in the blue water process. The chief work had been done by Dr. A. Parker in conjunction with Messrs. H. Kerr and F. S. Townsend.

Further particulars were then given by Dr. Parker, who stated that they had first tried to steam to the amount of 5 per cent. of the weight of coal in the retort, and had subsequently gone up to 20 per cent. and higher. The thermal efficiency had risen from 54 per cent. in the first test (without steam) to 62 per cent. in the fourth test, when 20 per cent. of steam was passing through the retort. The output of therms (in the form of water gas) was raised per retort per day, and more tar and ammonia were obtained, with steaming. Going beyond the 20 per cent. did not appear advisable, however, though complete gasification would be realised as their seventh test proved. As regards the Adderley-street experiments on water-gas making in a separate generator, clinkering was carried out every six hours, the generator was recharged every 41 minutes to a depth of 8 ft., and the cycle consisted of a blow of 1 minute followed by a 4-minute run, divided into up-steaming for 1 minute, down-steaming for $2\frac{1}{2}$ minutes and up-steaming again for $\frac{1}{2}$ minute. The average efficiency of water-gas production was 46 per cent., as mentioned already, allowing for the fuel required for steam to the generator and for driving the blower; disregarding this fuel, the efficiency was 56 per cent., whilst the efficiencies of the production of the extra gas, resulting from steaming the gas in continuous vertical retorts, at Uddingston ranged from 68 per cent. in the second test (6 per cent. of steam) to 57·6 per cent. (24 per cent. of steam). Thus the efficiencies in continuous vertical retorts were all higher than those obtained in separate water-gas generators, even without making allowance for the fuel required for raising the steam. At the same time, Dr. Parker added, the manufacture of water gas in an outside generator offered the advantage that it was more easily started up in case of emergency.

The potential heat loss of the blow gases accounted for 20 per cent. of the total heat supplied; the average amount of heat lost as sensible heat in the water gas, blow gas and undecomposed steam was 8·8 per cent.; the installation of waste heat boilers would considerably have reduced these losses, but the efficiencies in the Uddingston steaming tests might similarly be improved. Considerable trouble was caused by the deposition of a fine and yellow-brownish powder in almost all the sections of the plant beyond the scrubber. This dust contained 70 per cent. of silica, 10 per cent. of free sulphur, the rest being oxides of iron and aluminium, and the dust was probably due to the decomposition of a silicon hydride (SiH_4, corresponding to methane CH_4) and of sulphuretted hydrogen. The second part of the report dealt with the changes in the gas compositions occurring during a complete clinker to clinker period, valuable considerations for deciding upon the best methods of working at different full depths. The third part described special analytical methods adopted.

During the discussion of the report Sir Dugald Clerk dwelt upon the loss efficiencies of the blue water-gas reaction, to which Professor Cobb had drawn attention, with the heat losses. Mr. E. G. Stewart was more critical as to these points. He quite appreciated the value of the report, but he questioned the heat balances, which he had recalculated, as well as the statement of the report, that reliable conclusions as to the advantages resulting from waste-heat boilers in continuous vertical retort settings or blue water-gas plants, could not be drawn yet in the absence of actual working tests. Such data were, he thought, available.

The hour being late, Professor Cobb, in reply to criticism, said that the points raised could only be dealt with in detail, and he would therefore deal with them in writing.

(To be continued.)

LITERATURE.

American Tool-making and Interchangeable Manufacturing Design, Construction, Use and Installation. By Joseph V. Woodworth. London: Page and Co., 11, Gower-street. [Price 25*s.* net.]

This book is an eminently practical one, written for the men in the shops. The keynote is the apotheosis of the tool designer and the tool-maker. It is a volume significant of the vast revolution which, within recent memory has entirely changed the methods of the machine shop—a work that could not have been produced or conceived a few years since. Its author is well known as a capable writer on the subjects of which he treats. The matter dealt with is very largely that of jigs and fixtures, but many cognate matters which are germane to tool making are included. These relate to the operation of various tools, machines, and the working of metals, the whole forming a comprehensive and valuable *vade mecum* for the men in the shops.

Mr. Woodworth states succinctly the unique position occupied by the present-day toolmaker. While in the past, the highly skilled man laboriously produced by the exercise of his manual ability a number of parts of great accuracy in the construction of a mechanism, his labours are now directed to the scheming of a tool or set of tools to be operated by intricate machinery that will ensure the interchangeability of like parts in endless repetition. This involves very much more of detail than might be apparent on the surface. The carrying it through includes a design to be drafted, but which may be subject to modifications in the working out, frequently the making of a model, always the work of the pattern-maker and moulder, each of whom may be subject to variations in methods that make for economy, and finally the designing of tools to be set up in the machines, which will probably have to be modified when tested by the actual tool-maker. The result to be achieved is, that the perfected machine shall be built and completed in any numbers desired by the attendance of men who possess just average intelligence and skill, with minimum expense, yet with absolute interchangeability of parts. The whole story constitutes a chapter in the history of the applications of inventive genius and skill which may afford material for the fascinating pen of a future Smiles.

It is a difficult task, and somewhat unsatisfactory to attempt to deal with the immense and many-sided

subject of jigs and fixtures in a manner both minute and comprehensive. It seems better to give attention to broad principles rather than to the minutæ of selected examples that relate to particular articles of manufacture. There is almost too much of the latter in some technical journals, illustrated largely with photographs which really reveal very little of the useful details that would be helpful to designers. Mr. Woodworth eschews photographs entirely, and illustrates his descriptions with drawings only, which are clear and original.

The subject of drilling jigs—by far the largest group of jigs used, is amply treated in Chapters III to VII. In these examples the making of the jigs receives attention, and also the measures which are taken to locate the articles to be tooled in jigs and fixtures, and the methods used to locate jig holes in the lathe and the milling machine are also described. Examples of simple jigs are given in Chapter IV, with the fittings of their bushings, of locating spots, and of clamping devices—these being typical elementary forms having extensive adaptations. Some examples of jigged work follow applications of the foregoing principles. These, though designated as jigs, are combined with fixtures. In Chapter V the details are amplified, jig-fixtures of more elaborated designs being illustrated. These include operations on cams, on a hub, and a typewriter base, this latter having a large number of holes—56 to be drilled. Another example includes a dividing head for spacing, the index plate having three circles of holes.

Chapter VI deals with jigs for heavy machine parts, which present problems of a different, and generally more troublesome, character from those which are associated with the smaller jigs. The heavy weight is objectionable, since it tends to flexure, and hampers facile handling, so that lightening is generally necessary. The work is therefore often divided between marking-off main dimensions, to be tooled to templates, and performing localised operations only through jigs. Locating points and clamping methods also have to be modified in consequence of unequal shrinkages of the castings to be jigged. Some examples that illustrate these aspects occupy Chapter VI. Chapter VII deals with some novel jigs of indexing design, for spacing holes to occupy definite relations. They are interesting examples of their class, and illustrate an elaboration which is in essentials borrowed from some machine tools.

Chapter VIII treats of the special utilities of milling machines in tool-making, and interchangeable manufacture. It is in praise of the Universal machine of pillar and knee design—the machine of applied geometry. In continuance of the subject, simple milling fixtures occupy Chapters IX, X and XI. The last-named deals specially with fixtures for milling parts of drilling machines, as tables, heads and columns. Chapter XII takes up the employment of fixtures and arrangements in the turret lathe. These include the forming of irregular outlines from the cross-slide, a special box tool for the turret head, special chucks for holding bevel gears and spurs for boring and facing the bosses, and for tooling clutch pulleys all over, with sets of tools. There is a good deal of elaborate detail here, which is justified when the product is large. Other examples include a dome-shaped casting, an attachment for drilling and tapping six holes, the drill chuck working from the headstock, and the work fixture being inserted in the turret. Some of the capabilities of the screw machine are described in Chapter XIII, though with slight adaptations they are applicable to the turret lathe. Some of the examples are those of rigs-up for tooling work of irregular outlines with forming cutters, designs which are capable of ready modifications to outlines other than those given.

Chapter XIV deals with fixtures and tools for use in boring and drilling machines. This concludes the special subject of jigs and fixtures, which occupies nearly one-half the volume. The subsequent contents are of a varied character, treating extensively with tool production. Chapters XV to XVII deal as adequately as the space permits with the vast subject of milling cutters, their forms, uses, and methods of manufacture. The practice of hardening and tempering is treated excellently, being written for the man who has no elaborate equipment of furnaces, pyrometers and other aids. Chapter XVII dealing with drills, reamers and the allied tools, though necessarily abbreviated, is valuable. Broaches, Chapter XVIII, follows, the employment of which has grown much of late, and has been the cause of the design of several new machines, some being of large dimensions. There is a brief chapter on the use of micrometer calipers. The remainder of the subjects embrace matters of a miscellaneous character. One deals with the making of metal moulds for various small articles—for lead balls, pieces for telephone receivers, bicycle handle tips, &c., subjects seldom discussed, and therefore curious and interesting. The author has laid his own experience under extensive contribution, this experience, while that of a specialist, not being bounded by a limited horizon.

Chapters XXI and XXII are occupied with descriptions of some special tools, for making a cam, for cutting off brass rings from thin tubing, some examples of drilling, making collet spring chucks, drilling holes around a helical surface, milling in a drillling machine, and other examples culled from solutions of those practical problems that constantly arise in the machine shop, and which have frequently to be carried through by means of methods that are of a makeshift character. In cases of which some of these are typical, machines are used for doing work, not in the regulation way, but because they happen to be the best available in the shop at the time. Some of the examples here are those of work-holding fixtures and jigs as well as of tools. They are given as being illustrative of articles of the author's own designing. One of these is a tool for cutting fibre washers. Another, an engraving machine for checks, one for cam milling, chucks for cams, and a chuck for holding a three-cylinder casting for a gasolene engine, to be bored, the cylinders being disposed at angles of 120 deg. Various jigs and fixtures follow for milling, drilling, facing and counterboring.

The subject of power presses occupies a chapter, XXIII, with the making of dies for use on these, die-sinking, filing and hand-finishing. Chapter XXIV is devoted to the working of sheet metal in dies and presses, and Chapters XXV and XXVI with the making of punches and dies, including the drawing of deep shells in successive stages, bending, and forming, and the use of compound dies. Chapter XXVII deals with the rapid operation of power and hydraulic presses in the working of sheet metals—very comprehensive, and illustrated with outline diagrams of the essential mechanisms of the machines employed. Seaming, curling and wiring are treated fully, along with the punching of armature discs and segments. The important subject of the subpress is discussed in Chapter XXVIII. The making of dies for medals, coins, &c., has a chapter, followed by one on swaging. Another deals with the working of aluminium, giving many useful instructions relating to the subject. Chapter XXXII is devoted to the design and preparation of circular forming tools, and some odd matters besides.

Enough has been said to show that this is a valuable book of reference. It is encyclopædic in character and scope, it contains 516 pages, is wholly practical, has no photographs, is not disfigured by catalogue blocks, but is illustrated with 601 clear line drawings. A long time must elapse before such a work as this can become out of date, or be superseded.

Modern Motor Car Practice. Edited by W. H. Berry. London: Messrs. Henry Frowde and Hodder and Stoughton. [Price 31*s.* 6*d.* net.]

This book consists of some 575 pages and 300 illustrations. A short chapter is devoted to the history of the motor car, and the remainder deals with its general construction. Generally speaking, it does not deal with either the motor cycle or the motor lorry, though these are mentioned occasionally, and there are illustrations of a steam engine and boiler as used on one of the heaviest lorries.

A general description of ordinary motor car practice with regard to all the various parts of a car is given, and the question of fuels is dealt with as also the possibilities of using producer gas. The processes used for effecting repairs by modern methods of welding are also described, and there is a chapter on the X-ray examination of materials. One of the most useful chapters is the one on American electrical apparatus. There is no doubt that the Americans have been very successful in the application of electricity to the motor car, both for lighting and engine starting, and many European constructors might study their designs with advantage.

As a whole the information given is not very deeply technical and will be more useful to those who wish to have a general knowledge of the motor car than to the really technical man who wants information of details of design. It would also add considerably to the interest in the book if some of the constructions illustrated were described in greater detail.

Generally speaking the views expressed appear to be sound, but there are some points which are not very clear. Thus it is stated in Chapter XXV that "In the early days permanent joints between metal and metal were achieved either by riveting or bolting the parts together, more or less heavy flanges being used for strengthening purposes. Nowadays the constructors in nine cases out of ten would weld the joints and, providing the work be skilfully carried out, obtain parts which are cheaper to manufacture in addition to being both stronger and lighter in service." This would seem to imply that the majority of the joints of such parts as frames are now welded, which is hardly the case. Again, the statement that the 20-h.p. four-cylinder engine of to-day is lighter than that of ten to fifteen years ago seems to require modification. The fact is that the lightest car of this type in use to-day is the Ford—and this car has very probably very much the lightest engine. Now the Ford is of substantially the same design as it was over ten years ago, and has not been made lighter. Further, the general tendency of motor car engine design has generally been to make engines which have very small cylinders for their power, but as these entail very high speeds and high inertia forces the crankshafts, main bearings, crank cases, &c., are made very large and heavy, and the engines are therefore not as light per horse-power as engines running at a more moderate speed. A reference to the published weights of cars running in trials over ten years ago and of modern cars when actually weighed will show that the weights of cars so far from going down have often very considerably increased.

BOOKS RECEIVED.

Kritik des Zeitstudienverfahrens. Von I. M. Witte. Berlin: Julius Springer. [Price 15 *marks.*]

Motor Cycles and Side-Cars: Construction, Management and Overhaul. By H. Carbisbey. London: Cassell and Co., Limited. [Price 1*s.* 6*d.* net.]

Marine and Stationary Diesel Engines. Described and Illustrated with Numerous Original Formulæ for their Design and Instructions for Installation and Operation. By A. H. Goldingham. Second Edition. Revised and Enlarged with Appendix (*Diesel Engine Castings.* By F. J. Cook). New York: Spon and Chamberlain. London: E. and F. N. Spon, Limited. [Price 15*s.* net.]

Unemployment. The Cause and a Remedy. By Arthur Kitson. London: Cecil Palmer. [Price 5*s.* net.]

Handbook of Practical Smithing and Forging, Engineers' and General Smiths' Work. By Thomas Moore. Second edition. New York: Spon and Chamberlain: London: E. and F. N. Spon, Limited. [Price 7*s.* 6*d.* net.]

Concentration by Flotation. Compiled and edited by T. A. Rickard. New York: John Wiley and Sons, Inc.: London: Chapman and Hall, Limited. [Price 42*s.* net.]

United States Coast and Geodetic Survey. Special Publication No. 71. *Relation between Plane Rectangular Co-ordinates and Geographic Positions.* By Walter F. Reynolds. Washington: Government Printing Office. [Price 10 cents.]

Reinforced Concrete Tables: For Calculation of Lintels, Columns, Floor Beams and Slabs in Reinforced Concrete. By "Conrad." First edition. Newcastle-on-Tyne: Andrew Reid and Co., Limited. [Price 2*s.* 6*d.* net.]

Ministry of Munitions and Department of Scientific and Industrial Research. Technical Records of Explosives Supply, 1915–18. No. 2. *Manufacture of Trinitrotoluene (T.N.T.) and Its Intermediate Products.* London, Manchester, Cardiff and Edinburgh: His Majesty's Stationery Office. [Price 17*s.* 6*d.* net.]

University of Bristol, Faculty of Engineering.—Merchant Venturers' scholarships have been awarded to the following: H. A. C. Ridsdale (Crypt Grammar School), R. Robertson (Bristol Grammar School), A. E. Russell (Fairfield Secondary School), and R. H. Wilmot (Malmesbury Secondary School).

INDUSTRIAL NOTES.

THE Cabinet Committee has continued its deliberations in regard to unemployment, and is faced at the very outset with a most complicated task owing to the stringency of money. There was also, at first at all events, a certain reluctance on the part of the men to the appointing of a small number of Labour members to confer with the Committee on the practical measures to be taken for dealing with the situation. Finally, six representatives were selected to meet the Committee, these being Mr. R. B. Walker, Mr. E. L. Poulton and Miss M. Bondfield, for the Trade Union Congress, and Mr. S. Webb, Mr. Ramsay Macdonald and Mr. A. Henderson, for the Labour Party. After some correspondence with the Prime Minister, a meeting in which these six representatives took part was held last Tuesday, when Mr. S. Webb put forward the stimulation of normal production as the soundest method of relieving unemployment; Mr. Poulton stated the sums spent by the various trade unions in relief of unemployment amongst their members, and gave the views of the deputation in regard to housing and road-making in relation to unemployment; Mr. Henderson dealt with relief work of a national character for the development of enterprises of public utility; Mr. Ramsay Macdonald dealt with the question of maintenance to be granted to those for whom employment could not be found, and made proposals for mitigating the objections to this form of relief and for reducing it to a minimum. At the close of the meeting—which does not appear to have carried matters much further—the Prime Minister intimated that he would in all probability wish to see the deputation again in order to discuss with them the Government's proposals.

A true aspect of the situation is afforded by a speech made last Tuesday by Mr. J. R. Clynes, M.P., at the annual conference of the Textile Institute, Manchester, at which he delivered the annual Mather Lecture, his subject being "Industrial Relationships, Reform, or Ruin." After dealing with the stand taken in the past by both the employers and the workmen, Mr. Clynes said that for a better spirit to prevail, two things were essential; in the first place, the employers must abandon the idea of yielding only to the force of a strike, and for their part, the workmen in every case must honour the bargains which their representatives had made for them, renouncing the tendency to unauthorised strikes, which, in every instance, had resulted in very serious loss indeed to the workmen. Mr. Clynes added that employers in the main could do little for the workmen unless the latter lived up to the old moral motto: "a full day's work for a fair day's pay." To evade any service which workmen should perform, or to leave some things undone in the belief that thereby an opening for further employment was provided, was a delusion which had damaged the interests of the workmen far more than the interests of the employers. Unrestricted output was desirable because it would confer greater benefit upon the wage-earning classes than upon any other.

Mr. G. L. Bevan, in a letter to *The Times* for last Wednesday, on Stagnant Industry, says that the root evil still is the abnormal price of coal, adding that it is impossible to over-emphasise the fact that the industrial prosperity of England has been founded and built up on cheap fuel, and until we get back to it, it is hopeless to expect good times again. It has fallen, but it has not fallen enough; it has still got to come down another 30 pes cent. before we reach a proper basis of production. That this reduction will have to take place is as certain as sunrise, but the quicker it is recognised, the quicker we shall shake off our troubles, and it is not too much to hope that within three months of a 30 per cent. fall in coal, at least half a million additional workers would be reabsorbed into industry.

The following paragraph is taken from the same journal:—An applicant at North London Police Court yesterday, said that he had been a regular subscriber to his trade union for 13 years. Under the rules, he was entitled to 10*s.* a week out-of-work pay, but as he received only 4*s.* 1½*d.*, he went to the headquarters, where he found officials and clerks living like millionaires, and tables set out for dinner, with printed menu cards. He was told at headquarters that if he could not live on the amount allowed him, he must go to the relieving officer. The magistrate told the applicant that he might bring an action in the County Court and show them up.

The average net selling price of No. 3 Cleveland pig-iron for the three months ending September 30 having been certified at 131*s.* 5·13*d.* per ton, as against 126*s.* 11·56*d.* for the preceding quarter, the wages of the blast furnacemen on the North East Coast advance by 4½ per cent., this raising their wages to 77½ per cent. above the standard.

It is announced that by agreement the wages of the Cumberland coal miners have been reduced by 5*s.* per day, and the minimum wages reduced to between 7*s.* 10*d.* and 8*s.* 2*d.* per day.

The boiler makers on the Mersey resumed work last Monday, after a strike which lasted nine days, and was due to the introduction of oxy-acetylene apparatus for cutting holes in plates, cutting plates to shape, and so forth, which constitutes an improvement in that it expedites manufacture. We understand that the men at first claimed that 25 of their number should be allocated to each burner. A ballot on the point was taken last Saturday, and as a result of this, it is stated, the men have accepted a joint recommendation from a conference between their delegates and representatives of the Employers' Federation providing for the free use of the burners for hole cutting and cropping. The terms provide free use of a first burner on every ship or job, a second burner where the members of the Boilermakers' Society are employed on the ship or job, an additional burner on any ship for every ten members or portion of ten members of the Society employed on the ship or job, these numbers to include the men on the burning machine. The recommendation further provides for reconsideration of the matter in six months if necessary. We stated here on a former occasion (ENGINEERING, vol. cxi., page 657), in connection with a remark made by the Secretary of the United Patternmakers' Association, that the millennium will certainly be reached when trade unions threaten to strike unless the employers provide efficient plant.

The award of the Court of Arbitration presided over by Sir William Mackenzie, and set up by the Ministry of Labour, with reference to the claim made by the Shipbuilding Employers' Federation for withdrawing or reducing war period standard ship cycle of advances in shipbuilding and ship-repairing was made public last week. A first reduction takes place as from the beginning of the first pay period following October 8; a second as from the beginning of the first pay period following December 1; and a third as from the beginning of the first pay period following February 1, 1922. The advance of 20 per cent. in the case of "lieu" workers is totally withdrawn in instalments as above stated. In regard to piece-workers, the advances to riveters of 45 per cent. or 35 per cent. as the case may be are reduced to 10 per cent., also by instalments. The advance of 20 per cent. to caulkers and drillers is reduced to 5 per cent.; that of 10 per cent. to platers, angle-iron smiths, shipwrights, blacksmiths and semi-skilled workmen, to 2½ per cent. The parties to the arbitration were the Boilermakers and Iron and Steel Shipbuilders' Society, the Associated Blacksmiths and Ironworkers' Society, and the Shipwrights and Ship Constructors' Association.

The adjourned meeting between employers and men in the engineering trades, referred to in our last issue, took place on Thursday, the 6th inst., when no decision was arrived at in the matter of the withdrawal of the bonus granted by the Ministry of Munitions of 12½ per cent. for time workers and 7½ per cent. for piece workers. The employers proposed as a concession that the bonus be taken off in three instalments, on October 12, November 12 and December 12, provided the Trade Union Negotiating Committee recommended the men to accept it. The unions were unable to agree to this provision. The employers then offered to withdraw the bonus in four instalments, instead of three, the fourth instalment to be withdrawn on December 24; this offer, and one to take off the bonuses in three stages, on November 1, December 1 and January 1, were combated at the meeting, but the Negotiating Committee was empowered to continue the negotiations. Finally the men's representatives decided that a ballot without any recommendation to members be taken. The ballot is being taken this week; rejection of the employers' terms would result in a strike, as from November 1 very possibly.

The shipbuilding employers have made the same offer to representatives of the men in the shipbuilding trades, for the withdrawal of the 12½ per cent. and 7½ per cent. bonus which was granted to the men in these trades. The matter is also to form the subject of a ballot.

Speaking last Monday at the annual meeting of the United Steel Companies, Limited, the chairman, Mr. Albert Peech, said that the present industrial position was terribly handicapped by the cost of production, which was so very much in excess of the cost of our foreign competitors that trade could not possibly flow to us to the extent necessary to bring the works in this country to anything approaching full operation unless this state of things was remedied. No employer wished to reduce the wages of the workers for the mere sake of doing so. It was only the necessity of the position which forced it upon him; the worker, of course, resented it, but if he would only realise it his wages need not be greatly reduced. It was well within his powers to increase his output, which would counteract to a substantial extent the lowering of rates of pay which must take place. That there had been so little work during the last six months for the large number of men which the company employed had been a source of great regret to the Board. Taken as a whole, the employees of the company were good fellows, led away here and there by extremists, but still wishful to do what was right. The Board would be only too pleased to see them more fully employed, and whatever the Board could do to bring this about would be done, not only in the company's interests but in theirs. In the meantime, the strike of buyers still continued.

Meetings of the Executive of the Miners' Federation have been held regularly of late with a view to consider the disputed interpretation of the coal settlement accounts during the temporary period, in other words, the amount of the owners' liability in percentage on the 1915 standard rates to "help" wages. One point at issue, we understand, is as to whether the October wages are to be "helped" by the owners' profits in July and August—as the men contend they are to be—or by the figures for August alone. This affects the coal mines throughout the country, besides which there is a contention on the part of the South Wales miners in regard to the fixing of the September wages. Both the owners and the men have agreed to arbitration, and Sir William Plender, the independent chairman of the National Coal Board, who has been studying the matter, heard both sides last Wednesday. We shall deal with his award in our next issue.

So far as the steel industry is concerned, says *The Iron Age*, New York, the unemployment conference at Washington can limit its search for causes of unemployment to three. There are others, but if these three were remedied, the industry would soon be on its way to a scale of activity that would give work to tens of thousands of men who are idle to-day or working only a fraction of each week: (1) Transportation charges nearly double those of immediately pre-war time; (2) fuel cost more than double, and in some cases nearly three times that of 1914; (3) building trades labour cost double that before the war, with performance of building trades labour often below that of pre-war time.

The adoption of the principle of profit-sharing in large industrial undertakings in South Africa has been expounded in theory, but no one has as yet had the courage to put it into practice, says *The South African Mining and Engineering Journal*. It is noteworthy that the General Mining and Finance Corporation held a meeting with representatives of all sections of the workers at the Roodepoort United early in September, in order to discuss the principle of the matter. The profit-sharing procedure proposed was that the employees should forego one-half of the existing union rates of pay. Then the interest on the large amount of money which the company owed would be paid, and afterwards, before any profits went to the shareholders, a first charge on the further proceeds of running the mine should be the making-up of the wages to existing union standards. If, after this had been done, there still remained any surplus profits, the men should share in these with the shareholders. It appears that this experiment is being suggested in order to see if its adoption will in any way improve the efficiency of the workers, lack of which, of course, is at the root of all the troubles of the low-grade mines of the Rand.

German journals have lately published a table which gives figures of the workers involved in strikes in mining and in metallurgical works, together with the number of days lost, during the first six months of the present year for 24 nations. The first nation in the list is the United Kingdom, the figures being: Mining, workers 1,240,000; days lost, 69,000,000. Metallurgical works: workers, 261,000; days lost, 4,486,000. Total, 1,501,000 workers and 73,486,000 days lost. Among the other nations are Germany: total workers involved, 408,495 and total days lost, 5,356,505; the United States: total workers, 112,000 and total days lost, 1,616,000, Italy, 128,500 total workers and 1,020,500 total days; Spain: 84,700 total workers and 911,700 total days; France: 49,000 total workers and 562,000 total days. The grand totals for the 24 nations are as follow:—Mining workers, 1,703,700; days lost, 76,044,000. Metallurgical works, workers, 970,595; days lost, 14,283,655. Total, 2,674,295 workers and 90,327,655 days lost, to which the figures for the United Kingdom contribute by far the major part.

NOTES ON NEW BOOKS.

It is very remarkable how difficult it is for some men really to grasp mechanical principles. Within the past few years we have known an officer of the Royal Engineers to waste his time in attempting to devise a perpetual motion, and worse still we have known a professor at one technical college and a lecturer at another, to advance explanations, of certain physical phenomena, which were in obvious conflict with the doctrine of the conservation of energy. In all these instances the "crank" had successfully taken a course in theoretical mechanics, but his success must have been due to a certain facility in handling formulas and not to any real understanding of the subject. These instances, suggest that the text books in vogue had failed to lay adequate stress on the physical facts on which the science of mechanics was founded. In this regard, the treatise on "*Theoretical Mechanics*," by Professor A. E. Love, F.R.S., of which a third edition (price 30*s.* net) has just been issued by the Cambridge University Press, is a great improvement on many of its predecessors. The subject is not treated merely as suggesting elegant exercises in analysis, but its physical aspects are steadily insisted on. Though Einstein's principle of relativity is not mentioned in the book the concluding portion of the last chapter, dealing with systems of reference and the measurement of time, has no doubt been inspired by recent discussions, though the subject has been considered too recondite for treatment in an elementary work. The author presumes his readers to have a fair knowledge of the calculus, and is thus able to avoid the laborious "proofs" otherwise obtained which have disfigured so many text books in the past. The text covers the dynamics of a particle, and the simpler portions of the dynamics of a rigid body.

Readers of Marryatt will remember that when Mr. Nicodemus Easy was confronted with the dilemma of sacrificing his theories or his son, he adopted the second alternative, albeit with a sigh. Many former advocates of socialism must have found themselves in a not dissimilar predicament during the past three or four years. Until the Russian experiment, it was always open to the socialist to maintain that the uniform failure of his theories when applied to the test of practice, was to be attributed to the experiment having been made on too small a scale, but this defence, which was never a valid one, is now no longer available to even that remnant, which, as Abraham Lincoln observed, can "be fooled all the time." In the present condition of bewilderment to which recent events have reduced the many who were content to accept without any real investigation the maxims of Karl Marx and his disciples, the publication of "*The Facts of the Case*," compiled for the Economic Study Club by the editor of *Industrial Peace*, is highly opportune. The volume is published by Messrs. Simpkin, Marshall, Hamilton, Kent and Co., Limited, at 6*s.* net. It consists in the main of a long list of statements made by various socialist writers and speakers, and each statement is confronted with the actual facts of the case. The lack of knowledge exhibited in the quotations, which are demolished in the book under review, is almost incredible, and almost inclines one to accept the doctrine of "invincible ignorance," as held by certain religious sects.

The permanent literature relating to grinding practice—outside the articles in technical journals—is rather scanty. It is too much to expect that a slim volume of 112 pages, with 45 illustrations will cover this extensive field. But a concise elementary treatise on the subject has been produced in "*Grinding Machines and Their Use*," by Thomas R. Shaw, M.I.Mech.E., in Pitman's primers (Sir Isaac Pitman and Sons, Limited, price 2*s.* 6*d.* net). Mr. Shaw is an expert, and a man who is steeped in his subject generally knows how to state essentials lucidly, and to omit much of that detail which overloads rather than illustrates. The book is the basis of a series of lectures which the author delivered at the Royal Technical College, Salford. It treats of grinding wheels, cylindrical grinding machines, plane surface grinding machines, with details of construction and their care, and operation. As an elementary treatise for the student and mechanic it is to be highly commended.

"La France."—This is the title of a new weekly journal in the French language, the first number of which appeared on the 6th inst. It is issued at the price of 2*d.* weekly, the publishers being Messrs. Evans Brothers, Limited, Montague House, Russell-square, London, W.C. 1. The journal is destined for schools and colleges, and is a review of the French daily, weekly and monthly press; it is edited by a staff of teachers of French. Judging from the first number, this new publication will interest a wide circle of young student readers of both sexes, whom it will greatly help in the mastering of the French language; we welcome it with pleasure and hope it will have a large circulation.

SELF-WINDING ELECTRIC CABLE REEL.

CONSTRUCTED BY THE WAYNE ENGINEERING AND EQUIPMENT COMPANY, LONDON.

Figs. 1 and 2.

A winding reel, intended for carrying an electric cable used in connection with portable electric tools, electric lamps and similar devices which are required to be moved about freely, is illustrated in the figures above. It is being introduced under the name of the "Wayne" by the Wayne Engineering and Equipment Company, of 111–113, Great Portland-street, London, W. 1. The reel is designed to be secured to the ceiling of a workshop, and, as it is fitted with a swivel joint, the cable may be drawn out in any direction. An automatic stop is fitted, so that when the cable has been drawn out to any desired extent the reel is locked and will remain in any position in which it may stand for an indefinite period. The reel is fitted with a spring return, and when it is desired to wind up the cable it is only necessary to pull it down a small amount to release the catch, when it will coil up rapidly under the action of the spring. If the cable is held in any position the catch comes into play and locks it. The action is somewhat similar to that of a spring blind.

The purposes of the drum are the fairly obvious ones of rendering a flexible cable always convenient and handy for use, and at the same time protecting it from damage. No more of the cable need be unwound than is necessary for the job in hand, and there is no length of cable lying about the floor to be trodden on or damaged by being dragged round castings or similar obstructions. The cable coming from overhead also embraces a larger area of shop floor in its working range than does a flexible cable coming from an ordinary wall plug, and it is claimed that its use cuts down the number of working points very considerably. Machines and other obstructions in a shop frequently reduce the area which can be worked over from a wall plug, owing to the cable having to pass around them between the plug and the job in hand. The reel as secured to the ceiling with the cable partly pulled out is illustrated in Fig. 1. The overall size of the appliance is 14½ in. by 4 in., and it will accommodate 25 ft. of three-core cable.

It will be fairly obvious from Fig. 1 that the device consists of a fixed head, secured to the ceiling, carrying a bridle in which the reel rotates. A swivel joint is made between the head and the bridle, and sliding contacts are provided between the two, as is clearly illustrated in Fig. 2, and in more detail in the section of the whole apparatus given in Fig. 3. The sliding contacts, both of the bridle and the reel, are provided with springs, maintaining the two current carrying parts in good electrical connection. As already mentioned, a three-core cable is employed. The third core forms an earth wire, so that the frame of the electric drill or other part being used may be earthed as required by Home Office regulations. The main connections and the earth connections as they are made through the reel may be traced in Fig. 3. To facilitate the following out of the earth connection the letters *a* and *b* have been added to Fig. 3. The former letter indicates the point at which the end of the earth lead is secured, and *b* indicates the earth wire itself. The drum is wound up by a stout spiral spring, and the catch consists of a gravity-controlled pawl acting on a ratchet. When the cable is moved slowly the pawl falls into engagement with the ratchet and locks the reel. If it is moved rapidly the pawl is continually knocked out of engagement by the oncoming ratchet teeth. The ratchet actually consists of a series of screws secured into one of the side plates of the reel, which are made from No. 18 S.W.G. steel. They are nickel plated. The device in general is built up of pressed steel parts and is an excellent and well-made example of press work. Phosphor bronze bearings are provided, and insulating bushes at points where the conductors pass through holes in the parts or around corners.

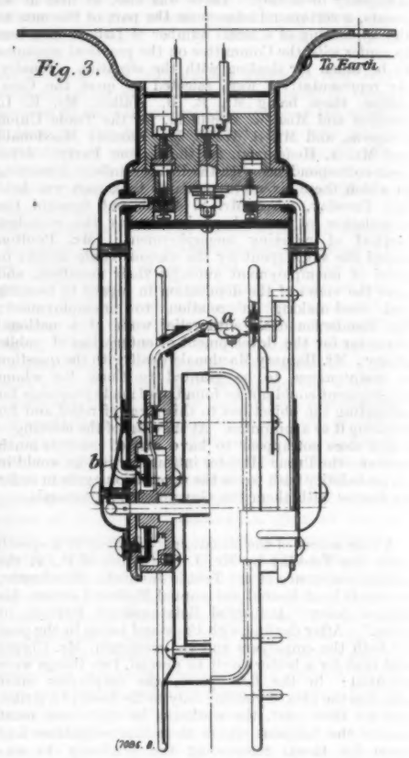


Fig. 3.

Chilean Railway Contract.—The Westinghouse Electric International Company has obtained a contract from the Chilean Government for the equipment, valued at 7,000,000 dols., required for the electrification of the State railroad between Valparaiso and Santiago, and the Los Andes branch. This is said to be the largest contract ever undertaken by an American firm, outside of the United States. The main line is 116 miles long, and the Los Andes branch is 28 miles in length. The latter forms the Chilean section of the trans-continental line to Buenos Ayres. The equipment will include 11 local passenger locomotives, 6 express locomotives, 15 main line freight engines and 7 shunting locomotives, together with five sub-stations of 4,000 kw. each. The locomotives are to be of Baldwin-Westinghouse manufacture. The power will be 3,000-volt direct-current. The overhead transmission will be constructed by the Errazuriz, Simpson Company, of Chile.

THE "CHARACTERISTIC CURVES" OF THE HEAT TREATMENT OF STEELS.*

By ALBERT M. PORTEVIN and PIERRE CHEVENARD.

AT the outset of a quantitative investigation on the influence of cooling, it should be pointed out that recent researches on the hardening of steel have led to the establishment with, in this instance, great accuracy, of the mutual relationship which exists between the two fundamental factors of all heat treatment—the temperature of heating and the rate of cooling. The final condition being a function of those two variables, it is easy to see the interest attaching to plotting a graphic representation of the result of a treatment by taking for any given steel, these variables as co-ordinates. This method leads, as the authors will presently show, to the establishment of what they have termed the "characteristic curves" of the heat treatment of the steel in question. Such curves not only combine, within a single diagram, the fundamental data of every possible heat treatment, but they also afford, as will be shown, a means of defining accurately the annealed and hardened states of the particular steel, and, therefore, constitute the basis and indispensable preliminary of every treatment properly carried out with a particular object.

Fig. 1.

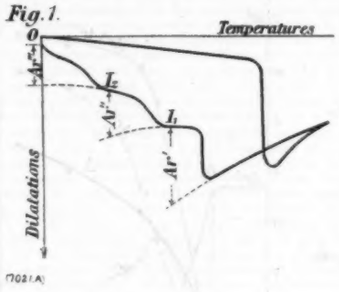
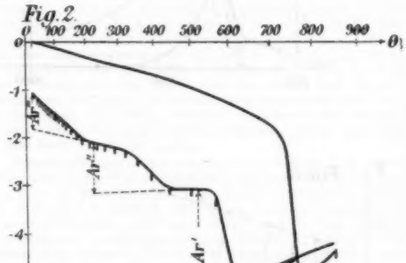


Fig. 2.



In order that such a graphic representation may be plotted properly, it is necessary that the values from which it is built up shall be susceptible of numerical definition so as to be capable of measurement. The authors will, therefore, first describe how they evaluate the rate of cooling and how they define the final state, that is to say, the result of the treatment.

Evaluation of the Rate of Cooling.—The authors will take into consideration only the case of simple heat treatments consisting essentially of heating to a temperature θc from which continuous cooling takes place according to a given law; a treatment which may be termed elementary, and which takes no note of more complex treatments in which the periods of heating may be varied, or in which the external conditions during the course of cooling are modified.† The latter, as a matter of fact, cannot be represented by any simple graph and the problem becomes complex, although still remaining susceptible of being linked up with the fundamental data furnished by the characteristic curves.

It must be conceded, in any case, that the law of cooling always remains the same, and that it can be regarded, in the first approximation, as definable by the initial temperature of cooling θc and by a single other parameter. The latter has been so chosen as to indicate the rate of cooling, for which purpose there may be adopted: 1. The initial rate of cooling, that is to say, the rate at the temperature θc; or 2. The average rate between any two determined temperatures, or its reciprocal, the duration of cooling, taken between these two limits.

If these limits comprise the regions of the transformation of the steel in the course of cooling, the heat liberated during these transformations affects the values of the average rate of cooling, or its reciprocal, the duration of cooling. For this reason it appears more accurate to select the initial rate of temperature θc as the measure of the rate of cooling, as by this means it is possible to define the conditions under which cooling takes place, independently of the perturbations introduced by the intervention of transformations. This is the plan the authors will adopt in the case of coolings in air, or in gaseous media, for which Newton's law may be regarded as approximately correct. On the other hand, when cooling is effected by immersion in a liquid the initial rate is found to be ill-defined, experimentally, and it is preferable, in order accurately to determine the rate of cooling, to take the average rate between two temperatures far enough apart, or the time taken in traversing such a temperature interval. Under these conditions a heat treatment would appear to be determined wholly by the values of two variables—the initial temperature θc and the rate of cooling V. These are the two co-ordinates of the diagram.

Definition of the Results of the Heat Treatment and of the Final State of the Steel.—In the case of a heat treatment having as its object the modification of the properties of a steel, the result will be defined in terms of those properties. It is obviously not possible to take all of them into consideration, as each would require its own special diagram. Amongst those properties the mechanical properties are, from an industrial point of view, the most important, but their measurement, when hard quenched steels are in question, is precarious and often illusory owing to experimental difficulties and errors.

The Brinell hardness Δ is still the property which

Fig. 3.

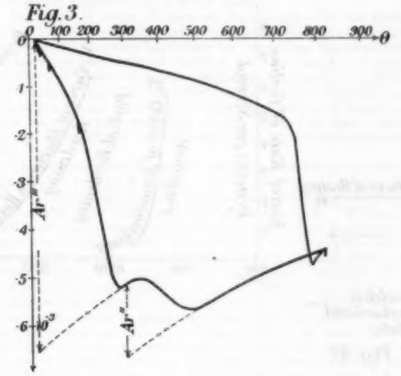


Fig. 4.

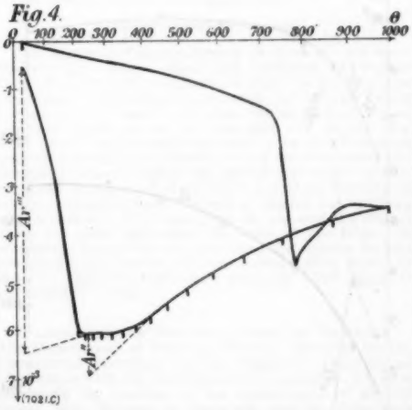
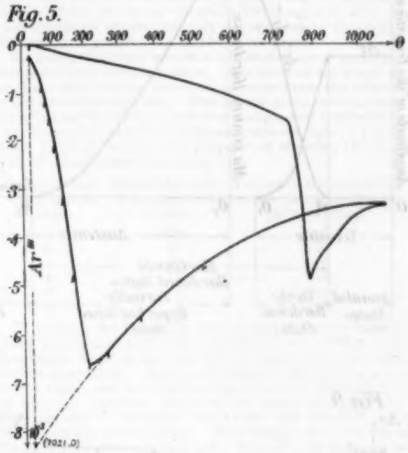


Fig. 5.



appears, in this connection, the most important, the least uncertain, and the only one capable of being used on samples independently of their shape or dimensions. For these reasons the authors have adopted it to define the results of heat treatments. It should, moreover, be noted that for a given steel the heat treatment always modifies the mechanical properties, such as breaking stress R, elastic limit E, and hardness Δ, in the same direction, and the elongation A, the contraction Σ, the impact resistance ρ and the angle of fracture on bending α, in the opposite direction.* A knowledge, therefore, of the variations undergone in respect of the hardness Δ yields information respecting those undergone by the other mechanical properties collectively.

The other physical properties are direct functions of the final state of the steel, that is to say, of the nature of its constituents. If, therefore, it becomes possible to define the latter, we possess a collection of data of the utmost value. For this purpose, however, the micrographic examination of the steel after treatment cannot alone be depended upon, for not only are the results first and foremost qualitative, and not susceptible of numerical evaluation, but they are also subject to considerable differences of interpretation, varying with the individual operator and the training and experience he possesses. The state of the steel is, however, the immediate result of the transformations it has undergone during cooling, so that a quantitative evaluation of the intensity of these transformations during cooling affords a means of defining the final condition of the steel. The foregoing deserves some explanation, and the authors will, therefore, recapitulate briefly and simply the relations which exist between the transformations of a steel during cooling and the resulting constitution.

Quantitative Evaluation of the Intensity of the Transformations Undergone during Cooling.—Two methods are currently employed to ascertain and estimate the transformations of a steel—the thermal method and the dilatometric method. With the latter alone the amplitude of the anomalies (variations in range which accompany the transformations) is independent of the rate of cooling. It is, therefore, this method which will be adopted by making use of the curves furnished by the differential dilatometer invented by one of the present authors.* The completeness and accuracy of the graph obtained with this apparatus allow of accurate measurements being taken along the curves.

It is known that if either the rate of cooling V, or the initial temperature θc, be uniformally increased, the lowering of the transformation temperature on cooling is not continuous and that the accompanying phenomena take place in the following sequence: The transformation, which, to begin with, occurs solely at a high temperature Ar', occurs in two stages when the rate of cooling reaches a value V_0, or when the temperature of heating reaches a value θ_0; one at Ar', at high temperature, and the other, Ar'', at a low temperature (about 350°). Thereafter, Ar' gradually diminishes while Ar'' gradually extends, Ar' ending by disappearing, while Ar'' reaches a maximum intensity and then decreases and disappears in turn. The presence of Ar' marks the formation of the complex $Fe_\alpha + Fe_3C$ (pearlite or troostite), that is to say, of the annealed state; Ar'' marks that of the commencement of the unstable solid solution α-iron + C (martensite), and therefore is characteristic of the hardened states. Absence of the transformation implies the persistence, at the ordinary temperature, of the solid solution γ-iron + C (austenite). These are the hyperhardened states.†

When Ar' and Ar'' occur simultaneously, troostite (Ar') and martensite (Ar'') are obtained; these are the partially hardened states. The gradual disappearance of Ar'' involves the presence of an increasing amount of untransformed metal, that is to say, of austenite, and thus the partly hyperhardened state is obtained. The limit between the annealed state and the partially hardened state is the only one which can be accurately defined by the appearance of Ar''. This is the transition through "the critical or minimum rate of hardening V_0" (when θc is constant), or through the "critical temperature or minimum of hardening Θ (when the rate of cooling V is kept constant‡)." V_0 and Θ_0 are likewise the maximum rates and temperatures of annealing.

The disappearance of Ar'' is, in certain steels, complicated by the intervention of a fresh reduplication of the low temperature transformation; there appears, below 200 deg., an Ar''' transformation which little by little supersedes Ar'', and then disappears, in its turn.

In order quantitatively to evaluate the relative importance of these various ranges of transformation, the authors have conventionally adopted the following rules. Fig. 1 represents a typical differential dilatometric curve showing the three ranges Ar', Ar'', and Ar''', simultaneously, the intensities being measured in the following way: Ar', by the vertical distance of the consecutive inflexion point I_1, from the extrapolated curve corresponding with the dilatationality at the stable hot-state. Ar'', by the vertical distance of the consecutive inflexion point I_2 from the curve extrapolated from the inflexion point I_1 (a curve which may broadly be identified with the tangent of inflection). Ar''', by its vertical amplitude measured at the surrounding temperature by extrapolating a curve below the inflexion point I_2.

Figs. 2, 3, 4, and 5 give actual examples of these measurements taken on three experimental curves;

* Paper read at the Paris Meeting of the Iron and Steel Institute, on September 6, 1921.

† As, for example, quenchings at falling temperatures, quenchings in two stages, intermittent quenchings, or annealings carried out at intermittent temperatures.

* Apart from certain very special circumstances such as superheating, tempering in the vicinity of the transformation point, and the temper brittleness known as Krupp-Krankheit.

* P. Chevenard, *Revue de Métallurgie*, September-October, 1917.

† A. Portevin, Lectures before the Ecole Centrale and the Ecole Polytéchnique, 1917-1919.

‡ Portevin and Garvin, Journal of the Iron and Steel Institute, 1919, No. 1, pp. 559 *et. seq.*

when Ar′ is missing, the amplitude of Ar″ is measured by extrapolating the curve of dilatability at the stable hot-state (Figs. 3 and 4), and the same is done in regard to A‴ when both Ar′ and Ar″ have ceased to exist (Fig. 5).

The variations in the intensity of Ar′ supply a measure of the proportion of troostite, and those of Ar″ and Ar‴ indicate the quantity of martensite. There are thus indirectly ascertained the characteristics of the state of the steel, that is to say, of its constitution after cooling. If curves of the variations in intensity of Ar′, Ar″, and Ar‴ be plotted (Fig. 6) in terms of one of the variables—*e.g.*, θc—it is possible by this method to determine the following: Θ_2 or the temperature of the disappearance of martensite (appearance of Ar″); Θ_1, the temperature of the disappearance of the troostite (disappearance of Ar′); Θ'_1, the temperature corresponding with the maximum martensite (Ar″ + Ar‴ maximum), and Θ_2, the temperature of the disappearance of the martensite (Ar″ + Ar‴ nil); and, therefore, to ascertain the zones corresponding with the annealed, hardened, and hyperhardened states. Similarly, on

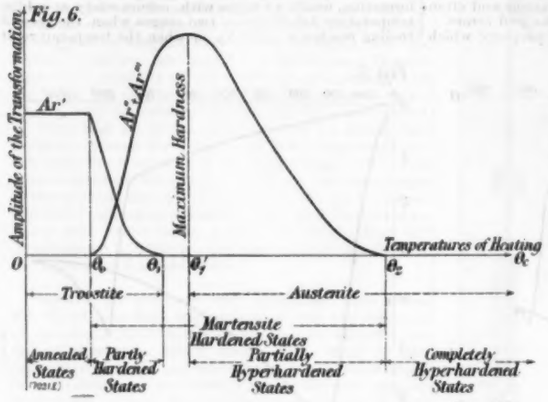
Characteristic Curves.—By varying simultaneously the initial temperature of heating c and the rate of cooling V_0, it is possible to plot the geometrical area of the various characteristic limits of the different states in terms of θc and of V, taken as co-ordinates in the plane θcV. By these means are obtained the "characteristic curves of heat treatment for the given steel." They comprise, more particularly:

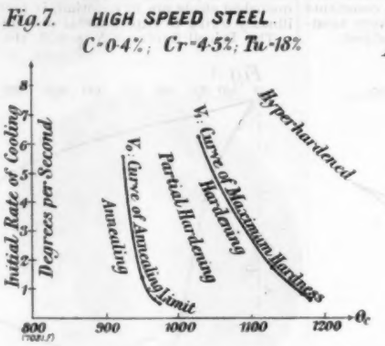
1. The curve $\theta c V_0$ or $\Theta_0 V$, giving for each temperature θc the critical hardness value V_0, or else the maximum temperature of annealing Θ_0 for each rate V of cooling. This curve separates the annealed states, devoid of martensite, from the hardened states, containing martensite. It is, therefore, the curve of the annealing limit. It rigorously defines the hardening capacity of the steel.

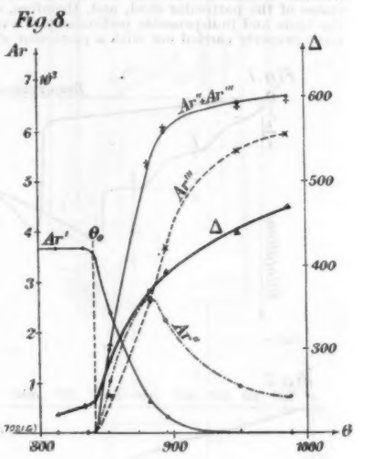
2. The curve $\theta c V_1$ or $\Theta_1 V$, of maximum hardness, or of the maximum amount of martensite. This is the curve of maximum quenching, which similarly marks the limits between the partially hardened and the partially hyperhardened states. This diagram is completed by adding, in the region of the hardened states, curves

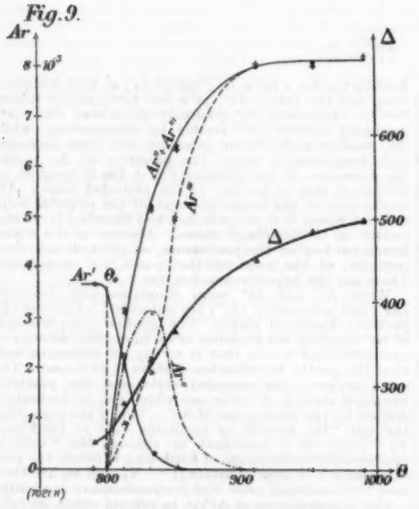
Examples of Characteristic Curves.—The plotting of a diagram of characteristic curves for heat treatments comprises a considerable number of experimental determinations forming a complete heat-treatment research on steel, of which investigations hitherto published afford no parallel. As has already been said the most important of these curves, the curve showing the limit of annealing or the curve of the commencement of hardening, is one which can be plotted with considerable accuracy, as it can be decisively determined by three methods simultaneously—micrography, the transformation-point determination, and by ascertaining the hardness.

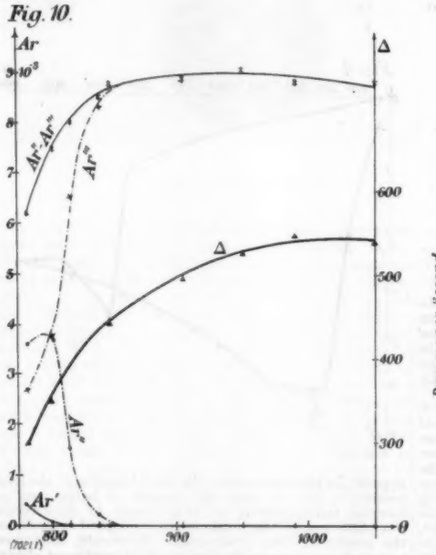
It is possible to quote certain examples of these latter curves in, however, a somewhat fragmentary state. In the research by Edwards, Greenwood, and Kikkawa* on chromium steel containing 0·63 per cent. of carbon and 6·15 per cent. of chromium, there will be found (Fig. 15 of the original memoir) data allowing of the plotting of this curve (as well as of portions of the isohardness curves) within the range comprised between periods of two to twenty minutes cooling between 836 deg.

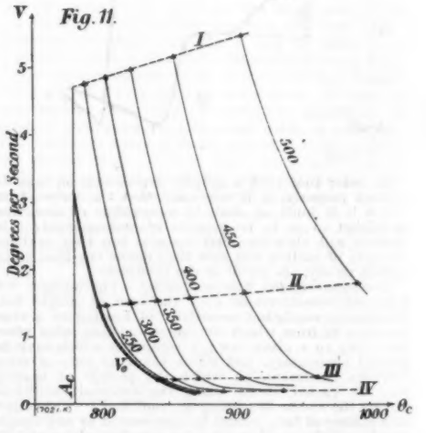












taking the rate of cooling, the rates V_0, V_1, V'_1, V_2, . . . , limiting these various regions, can be found.

The most important and the best ascertained of these limits is that which separates the annealed states from the hardened states, and which is distinguished by the appearance of Ar′ and by a rapid increase in the hardness, in terms of the variable under consideration. The next in importance is the maximum of Ar″ or of Ar″ + Ar‴, which is likewise the maximum of the hardness. Its practical importance is obvious, and it also marks the limit of the hyperhardened states.

The limits of the disappearance of the troostite and the martensite are much less important and less accurately determined, nor should too much reliance be placed on their indications, or on the fact that experimentally the disappearance of the troostite and the maximum of martensite are not found to be in agreement. There is nothing, moreover, to prevent these secondary zones overlapping one another, which sometimes leads to the existence of the mixture troostite-martensite-austenite. What is really of importance in these hardened states is the hardness. An investigation of the latter will, therefore, take the place of questions relating to the constituents, the more so as, by ascertaining the position of the maximum hardness and examining the drop in the hardness in hyperhardened zones, it will be equally possible to ascertain the limits of the commencement of hyperhardening and of the disappearance of martensite,

of isohardness which serve to mark the limit of the various hardened and hyperhardened states. These are the curves of the surface level (θcVΔ) which is formed from two planes, the intersection of which is continued in the direction of the curve limiting the annealed state and shows a crest extending towards the curve of maximum hardening. By these means are obtained a complete graphic expression combining all the conditions essential to hardening. It will be seen that the latter problem is entirely indeterminate, as any particular point on the co-ordinates θc and V may occur within the area of the plane. Even if it be sought definitely to determine amongst the hardened states a particular state corresponding with the hardness to be attained, its selection would be defined by the co-ordinates in any one of the points in the corresponding curve. Amongst this infinity of solutions choice can be made of the most suitable by bringing into consideration the practical conditions obtaining, such as rate of cooling and temperature of heating, as well as the parasitic phenomena* such as superheating, deformation, internal stress, cracks, &c., accompanying the heat treatment.†

and 546 deg. These authors also give, within the same range, the curve of the disappearance of Ar′ (Fig. 14). One of the present authors‡ has shown, partly by the dilatometric method, curves of the annealing limit of carbon steels containing 0·22, 0·30, 0·39, 0·49, 0·59, and 0·82 per cent. of carbon. Finally, Fig. 7 shows‡ the annealing limit and maximum hardness curves of a high-speed chromium-tungsten steel (carbon, 0·4 per cent.; chromium, 4·5 per cent.; tungsten, 18 per cent.). This diagram presents the three ranges of the annealed, partially hardened, and hyperhardened states.

The authors have plotted characteristic curves for various types of steel selected amongst those most important industrially and most interesting from the variety of states practically obtainable, notably manganese steels readily susceptible of being hyperhardened, and nickel-chromium steels. They propose to give the results obtained, up to the present, on one of the latter steels.

Characteristic Curves of a Nickel-Chromium Steel.—The nickel-chromium steel had the chemical composition given in the next column:—

* The sense in which the authors use this word is probably the philological one of "attaching erroneously or by false analogy." [Note by translator.]

† See A. Portevin, *Chimie et Industrie*, 1919, vol. ii. p. 1154.

* *Journal of the Iron and Steel Institute*, 1916, No. I., page 114.

† P. Chevenard, *Revue de Métallurgie*, 1919, vol. xvi. page 77.

‡ *Ibid.*, 1920, vol. xvii., page 688.

	Per cent.
Carbon	0·50
Manganese	0·30
Nickel	2·65
Chromium	1·60

The researches were made by the dilatometric method on samples 3·5 mm. in diameter and 50 mm. in length, and supplemented by determinations on the Brinell hardness carried out under the following experimental conditions.

Conditions of Heating and Cooling.—Heating was effected in an electric resistance furnace with a very nearly constant rate of 250 degree-hours for all the tests. The temperatures of heating, θc, are shown in the diagrams as registered by the dilatometer.

Four methods of cooling were employed :—1. Spontaneous cooling in air after withdrawal from the furnace. 2. Cooling in a little metal formed of a tube of baros (an alloy devoid of transformation states), heated together with the sample, and air cooled after withdrawal from the furnace. 3. Cooling within the oven by interrupting the heating current, &c. 4. Retarded cooling in the furnace by gradual reduction of the heating current.

In each instance the temperature on cooling decreased closely in approximation with Newton's law. On the other hand, the rate of cooling at any given temperature is practically independent of the temperature of heating, so that a typical cooling curve corresponds with each mode of cooling. Hence the employment of the "initial rate" to characterise the rate of cooling, and, as Newton's law is very closely followed, the points relating to any given mode of cooling distribute themselves in the final diagram (θcV) along a line cutting the axes of the abscissæ at the surrounding temperature.

Measurement of the Dimensions Characterising the State of the Steel.—Figs. 2, 3 and 4 give examples of curves registered, with dimensions of the amplitudes of the transformations, as already described. These dimensions allow of curves being plotted for each mode of cooling, giving the variations in the amplitude of Ar′, of Ar″, of Ar‴, &c., of Ar″ + Ar‴ in terms of the temperature of heating. Figs. 8, 9 and 10 give these curves for the three methods of cooling (1), (2) and (3), as well as curves of the Brinell hardness Δ in terms of the same variable θc. This hardness was determined by a series of ball impressions (1·6 mm. diameter and pressure of 25 kg.) distributed along the length of the test-rod, the cylindrical surface of which, with this object in view, had been lightly planed under water (to obviate any tempering effect due to heating), so as to obtain the little flat surface necessary for this kind of test. Each test-bar thus received seven ball impressions, the diameters of which were measured under the microscope. The tests were not considered satisfactory, except when the individual divergences were less than 5 per cent. from the mean.

Results Obtained.—An examination of Figs. 8, 9 and 10 brings out clearly the sequence of phenomena of hardening already described. The particular interest attaching to this steel is that it affords an excellent example of the double stage occurrence of Ar″ and Ar‴ of the low temperature transformation, a doubling hitherto but little investigated. Here the appearance of the two points Ar″ and Ar‴ takes place simultaneously at the temperature Θ_0, and at the same time as the intensity of Ar′ begins to decrease. There is thus, in this instance, a triplication of the transformation Ar″, which is nil at Θ_0, increases until it attains a maximum of intensity, and then decreases almost to zero while the amplitude of Ar‴ increases steadily the while. The total intensity, Ar″ + Ar‴, which determines the quantity of martensite found, varies in the inverse ratio of that of Ar′ (troostite).

The rise of the temperature, θc, reached tends to make the reduplication of Ar″, Ar‴, at low temperature disappear. As this rise of temperature leads to the completion of the solutions of the iron carbide and to the homogeneity of the solid γ solutions, this fact conduces to support the view, taken by the authors, as to the connection between the existence of multiple points at low temperature, and the lack of uniformity of concentration of the solid solution.

The rate of cooling acts in an analogous way, the increase in the rate of cooling tending to make Ar″ disappear. The two points Ar″ and Ar‴ exist nevertheless in the case of method 4 of cooling, so long as the temperature of heating does not exceed 850 deg. to 875 deg. With the steel in question the authors were unable, within the limits of heating and cooling adopted, to obtain hyperhardening. The Δ curves and those of Ar′ + Ar″ show that the maximum is not attained, or, at any rate, is not appreciably exceeded.

When the amplitude Ar′ + Ar″ becomes practically constant it will be seen that at the same time the rise in hardness becomes much less rapid, which shows that the neighbourhood of maximum hardness is being approached. In order readily to attain to hyperhardening, it would be necessary to have recourse to much higher rates of cooling, which the authors have not had time to undertake.

The diagram of the characteristic curves summarising the whole of the determinations is given in Fig. 11. It comprises the curve of the limit of annealing, or curve of the critical rates of hardening V_0, separating the region of the annealed states from that of the hardened states; and in the latter region the succession of curves of isohardness corresponding with the values of Brinell hardnesses varying from 50 to 500. As has been said, the isohardness curves relating to hyperhardening were not taken, so that this diagram does not exhibit the curve of maximum hardness. Moreover, it cannot be hoped to collate into one plan and on one common scale the entire appearance of characteristic curves, given the considerable range of cooling rates obtainable.* It is necessary to limit the inquiry, in the first instance, to the most useful and most serviceable portion, for each steel. Even within these limitations the diagram of characteristic curves furnishes a collection of facts as to heat treatments incomparably superior to the often somewhat inchoate collection of numerical data hitherto accumulated in connection with the heat treatment of steels. Very often the basic considerations relating to mass and rate of cooling, cannot be deduced from these observations, or expressed numerically, so that it becomes impossible to foresee what modifications may be required when the size of the pieces, or the nature of the cooling medium, is changed.

Numerous and important researches have now supplied data as to the cooling capacity of liquids and gases, and in order to apply them to practice there should now be plotted, with no less accuracy, and for each type of steel, the curve showing the relationship between the rate of cooling and the effect of treatment, taking into consideration, more particularly, the part played by the second of the fundamental variables—the temperature of heating. It is to the questions raised by the latter problem that the plotting of the characteristic curves can supply answers, as they combine, in a readily utilisable form, all the data furnished as to heat treatment, and are the only means of ascertaining, with any degree of precision, the hardening capacity of a given steel.

Influence of Other Factors on Hardening.—In the foregoing the authors have taken into consideration only the influence of the two fundamental variables, temperature of heating and rate of cooling, on the results of heat treating a steel of given chemical composition. But, given these factors, the effect of treatment depends on other secondary factors; the law, and period of heating, and the original structure of the steel, the final state being a resultant of all its previous heat-treatment history.

The characteristic curves are not, therefore, strictly applicable except when the latter factors are constant, which might lead to the belief that their signification and utility must be correspondingly restricted. Without, however, entering into details, it will suffice to observe that the original state, the result of the previous heat-treatment history, can be reduced to a typical form by preliminary heat treatments, and that, besides this the perturbations which may be introduced may in many instances be entirely obviated by an appropriate selection of the law and duration of heating. In other words, in this group of secondary variables it is possible to arrange matters so that some of them will destroy the effect of others, and that the thermal behaviour of the steel shall agree with the data given by the diagram of characteristic curves of heat treatment.†

THE RAILWAY CLASSIFICATION OF GOODS.—We have received from Messrs. Hirst and Adamson, 13, Market Cross Chambers, Huddersfield, a chart relating to the alteration in classification of goods for railway rating purposes. The chart is to some extent preliminary as the classification is not yet complete, nor are the new rates fixed. It is arranged so that, so far as information goes at present, it is possible to read off at a glance the percentage above or below the present rate which the new rate may be expected to show, for any of the twenty new classes, excepting Class 1, which at present has not been clearly defined. The chart gives the old and new classes along the head, and down the sides, of the table, the percentage being found by following the column for one classification as far as the line corresponding with the required class in the other grouping. The chart is published at 1*s.* 6*d.*

TRANSMISSION OF ELECTRIC POWER TO DENMARK.—The Department of Overseas Trade is informed by the Commercial Secretary to His Majesty's Legation at Christiania, that the Scandinavian Commission, which is discussing the question of the transmission of electric power from Norway to Denmark, met in Christiania on August 19, and that a number of lectures were delivered on the following subjects: Existing and projected power installations in Norway which may be affected by the question of the transmission of power; explanatory description of the Nore power installation; information regarding power lines; the question of price in connection with the sale of electrical energy in South Norway; the employment of direct current in the transmission of power to Denmark, &c. After their meetings the Commission visited a number of Norwegian power stations, namely Vamma, Solbergfos, Morkfos and Nors. The Commercial Secretary learns on inquiry that the possibility of the scheme being realised in a not too remote future is now considered to be much greater than it was before. Some experts consider it probable that Norway will deliver power either from power stations on the River Glommen or from Nore, and that she will herself undertake the transmission of this power as far as the Swedish border, from which point the further transmission would be undertaken by Sweden. It is proposed to employ a tension of 200,000 volts, which exceeds the capacity of any cable which has hitherto been manufactured.

* If it were desired to reproduce on the diagram, Fig. 11, and on the same scale of rates, the portions of the critical curves of the hardening of carbon steels actually plotted, the space required for their development would amount to 40 yards in height.

† An exception must be made to the foregoing: that presented by certain nickel-chromium steels which are abnormally irreversible (A. Portevin, *Revue de Métallurgie*, 1913, vol. x. pages 797 and 808).

FUNDAMENTALS OF INTERCHANGEABLE MANUFACTURE.*

By CHESTER B. LORD, Battle Creek, Mich.

IN dealing with so broad a subject as interchangeable manufacture, it is well to remember that in the course of time many false traditions and pseudo-scientific conditions are built around a process or system, either glorifying it unduly or condemning it beyond its deserts. This makes it necessary to be iconoclastic and to tear down that we may build upon a firmer foundation, sometimes rearranging the former material and sometimes rejecting it. Likewise, it is well to start out with certain fundamentals plainly stated, and any discussion or theory that contravenes these fundamentals is useless for our purpose.

The first fundamental is that no two things are alike; the second, that the difficulty of maintaining accuracy increases in geometric ratio with each added accurate dimension on the same piece; the third, that no machine or tool under stress can be accurate; the fourth, that the manufacture of interchangeable parts in quantity is a matter of percentage; and the fifth, that, irrespective of the method used, quality is a matter of insistence.

The nearest approach to mechanical perfection that we know of is found in the Johansson gauges, or was until the advent of the Hoke gauges; but, within their limits, these are by no means interchangeable and the interferometer shows not only a variation in size but a difference in parallelism of the same piece.

Securing one very accurate dimension on a piece is a comparatively simple matter. The ease of securing two accurate dimensions, however, depends upon the relation of the second to the first. The figures given in the following table are based upon practice and general impressions, but the author believes them accurate enough to justify their publication for the purpose of showing the high cost of unnecessary accuracy:—

No. of dimensions on one piece.	Probable number of perfect pieces.	Per cent. estimated increase in ratio of cost per operation.
1 ...	100 ...	0
2 ...	90 ...	30
3 ...	50 ...	75
4 ...	15 ...	100
5 ...	5 ...	200
6 ...	0 ...	500

In making the foregoing statements the author has in mind automatic and other machines where the close-dimension work is done at one setting and in manufacturing quantities. Some will dispute the figures given in the table, and will declare that it is not good practice to attempt finishing pieces in the automatic, but that they should be roughed out there and finished on a shaving lathe or elsewhere. This brings us to our third fundamental, and we may ask: Why should they not be finished complete when a good automatic must, in the nature of things, be (and is) as accurate as a single-purpose machine on a single accurate dimension? It is not accurate on several close ones, however, and accepted practice confirms this statement, and the reason why it is not, and cannot be, accurate is because of conflicting stresses.

There are many firms the engineering departments of which really believe they are producing an interchangeable product of close dimensions, but their inspection and manufacturing departments could tell a different story. It is not bad workmanship, or lax inspection, that is responsible for their failure to produce such work, but the oft-times unnecessarily close tolerances specified on unimportant dimensions, or the insistence of close ones on several dimensions of the same piece, and it is well to stop and consider what may happen, say, to a piece of apparatus after it has been in service for some time when initially it required the centres of two shafts to be held within one-half thousandth of an inch.

Interchangeable manufacture requires both relative tolerance and specific tolerance. Relative tolerance has to do with its relation to the part to which it assembles, and does not necessarily affect the tolerance of the specific dimension. Specific tolerance is that tolerance on a specific dimension required to render a particular part easy to manufacture, or to take care of the wear on tools.

Any part increases in cost with each succeeding operation, and the probability of loss should decrease in the ratio of its added value. This result should be obtained, first, by a design having in view its relation to subsequent machining operations, and, second, through the proper sequence of operations relative to their difficulty, and sufficiently divided. This leads us up to the question of registration. Automobile engine builders cast lugs on their cylinders to ensure parallelism of bore; adding machine and phonograph castings sometimes have bosses cast on, to take the pressure of milling or drilling operations. It is also true that sometimes we insert a pin in a drilled hole to guard against movement, but we do it only at times and usually as a matter of convenience, whereas it is a matter of necessity, and it will usually cost less to drill special holes or machine special lugs for registration and resetting than to attempt to do the work in fewer complex operations.

And nearly as important as registration is the question of clamping. One of the fundamentals laid down was that a machine under stress could not be accurate. This is just as true of a piece being machined, and unless a part is designed with its subsequent machining operations in view; unless it is supported sufficiently near its pressure centres; unless it has a three-point support

* Paper read before the American Society of Mechanical Engineers, at the Chicago Meeting, May 23–26, 1921.

with the holding or clamping pieces immediately over them (and in the case of a drill jig, independent of the part that carries the bushings), then that piece cannot be accurate. This is true of drilling always, of milling generally, and of turning sometimes.

How tolerances shall be indicated; whether they shall be identical, independent, or overlapping; what the law of probability and what actual trial demonstrate as the probability of overlapping or identical tolerances interfering; the percentage that may be expected at different parts of the tolerance, and the lessons to be learned therefrom, are subjects calling for extended treatment by themselves. The same is true of inspection, of machining methods, of analysis of product.

The automatic screw machine will, of course, always be with us, for in that we meet ideal manufacturing conditions as nearly as they may be met. But the fact that the single-spindle screw machine persists and is even exclusive in the small-part field is still further corroboration of the price we must pay for accuracy. The question of accuracy is, of course, relative, as is the question of rigidity of machine; but it is important in its bearing upon the cheapness of manufacture by determining the number of cuts, retapping, reaming, grinding, &c., that are necessary.

The law of compensation applies to mechanics as well as elsewhere in industry, and when we attempt to work to closer limits at the expense of increased operations, we must pay somehow. This is not to be considered as an argument against such a procedure, but an appeal for commonsense in interchangeable manufacture—not to make the work easier, but to reduce the cost—and the firms that are really making a good interchangeable product are those that have analysed all the different conditions and hold the extremely accurate dimensions at a minimum.

Neither should it be thought from what has been said that close dimensions may not be necessary or desirable. Some companies require them much closer than do others. It then becomes a question of whether the price received for the finished apparatus is commensurate with the close limits imposed. If not, then it is a matter of increasing the tolerances so as to permit manufacture on a cheaper basis. In other words, the percentage of rejections that can be tolerated must be figured out and kept within that limit. For instance, an apparatus costing $10.00, for which a liberal price is asked and received, an allowance of 50 cents per apparatus for rejections may not be excessive. If, on the other hand, the price is close, 50 cents may mean the difference between profit and loss. This is a matter of policy to be settled by the administration and not by the shop, although we very often lose sight of this fact.

In the author's opinion, there are no such things as close tolerances. All are relative, and we only court trouble when we try to take too many steps at once. One-half thousandth is only 5 per cent. of a ten-thousandth, and the chance of securing that accuracy in quantity in one step is about 5 per cent., multiplied by the extra cost. But one-half thousandth is 50 per cent. of one thousandth, and the probabilities are increased in the same ratio, so we may lay it down as a truism that subdivided operations are a function of accuracy.

Analysing our fundamentals, we find that there are three ways in which interchangeable parts may be secured:—

(*a*) By obtaining a percentage of good ones, with close tolerances.
(*b*) By giving individual attention to each piece.
(*c*) By employing liberal allowances.

The first is wasteful and the second is not manufacturing; the third one means liberal unnecessary allowances and close necessary ones, with the operations so divided that each individual working upon the part has but one thing to do. Thus, on a small shaft with six diameters all ground to a 0·0005 in. limit, there should be six roughing and six finishing operations, because different wheels may be used; because less skilled men may be employed with less chance of scrap; because the wheel will be in better condition and will not need dressing so often and the operator will not have to change his sense of proportion, "hog off" material one moment and hardly touch it the next; because the finishing operations may always be done on the most accurate machine; and last, but not least, because as a rule one man can finish more work to close dimensions in four operations than four men can in one operation.

Let us not delude ourselves, however, that interchangeable manufacture or standardisation is all profit and has no penalties. The French, even in large business, recoil from the idea of standardisation, and this feeling has saved them through the ages from the rigidity of an arrested civilisation. I am not competent to say whether the artistic qualities of the French are the result of their fight against standardisation or whether it is the cause. Suffice it to say that no country that manufactures on the scale that France does and employs standardised methods, can either duplicate her excellence of manufacture or produce the artistic or scientific results she obtains. We must somehow pay for the repetition we call standardisation, specialisation, or interchangeability, and, as usual, the toll is collected from the intellectual.

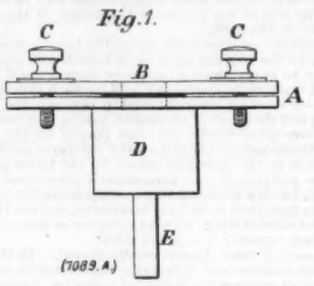
POLLUTION OF THE AIR OF MANCHESTER AND SALFORD.*

By William Thomson, F.R.S.Ed., F.I.C.

My experiments were made at my laboratory near the City Art Gallery, at the corner of Princess-street and Mosley-street, in Manchester. I discovered that there are two kinds of suspended impurities in the atmosphere of large towns; the one consists of fine particles of dust which fall rapidly to the ground and which are evidently largely blown and carried from factory chimneys in the form of ash dust; or from the streets during windy weather; the other form being of a fine impalpable dust, the particles of which are so minute that they remain in an almost colloidal condition suspended in the air; and these particles fill every corner of every room in the houses of large towns. This impalpable dust or smoke I found could be filtered from the air and by passing measured quantitites through white filter or blotting paper the fine smoky suspended matter was deposited on the surface of the white paper, leaving on it a stain varying in depth of colour at different times of the day and on different days, from a faint grey to a deep black.

* Paper read before Section B of the British Association at Edinburgh, on September 13, 1921.

Fig. 1.



My first experiments were made by placing a disc of white blotting paper (see Fig. 1, shown in section) between two brass plates A, covering the holes B provided in each, fixed firmly by a screw C at each end of the plate. A piece of brass tube D was soldered on to the lower plate about 1 in. deep, closed airtight by a disc of brass bearing a short brass tube E, which was attached to a water vacuum pump through which 3 cub. ft. of air was drawn every half hour. I noticed that these discs of paper thus used became darkened from a light grey to various degrees of darkness.

On one day I commenced at 12 o'clock noon and passed 3 cub. ft. through the paper up till 12.30 p.m. I changed the disc of paper between 12.30 p.m. and 1 p.m. and again set the pump going to draw 3 cubic feet of air between 1 and 1.30 p.m. This was continued every hour till 11 o'clock in the morning following. When these discs were arranged side by side it was seen that the deepest marks were left at the hours of 10, 11 and 12 in the morning; and that they became less marked towards midnight; and from then on to 6 in the morning there was least deposit or darkening of the paper through which the air had been filtered.

It seemed interesting to determine in this way the degree of the pollution of the atmosphere from hour to hour and from day to day; and I therefore devised an electrical apparatus which automatically pulled a ribbon of blotting paper ½ in. every half-hour, over a hole ½ in. by ¼ in. in a brass drum, the air from which was being constantly drawn through the paper by pumps actuated electrically. This left a series of 48 impressions for each day, which could easily be compared relatively to a standard of shade values to which approximate figures were accorded.

Some of the impressions were as black as ink, so that it was impossible to give them more than roughly approximate values. To obtain more accurate figures the electrically-fitted clock was afterwards arranged to pull the paper over the hole every 15 minutes. The chart (Fig. 2) is a photograph of a week's record showing half-hourly impressions. After nine months' constant working of the appliance, the number values of the impressions for each half or quarter hour of each day of the week were added together and divided by the number of such days; this gave the average pollution at each half hour on each day of the week; and the chart (Fig. 2) shows how they vary.

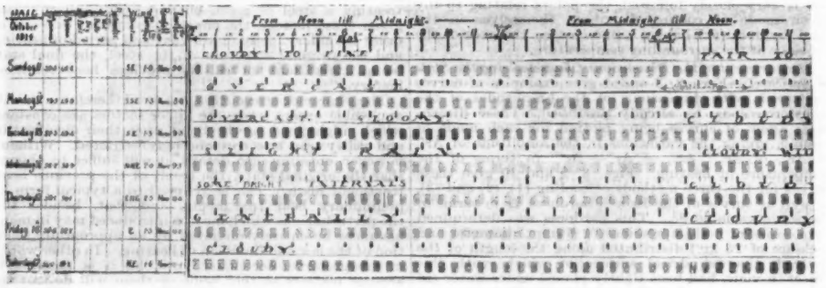
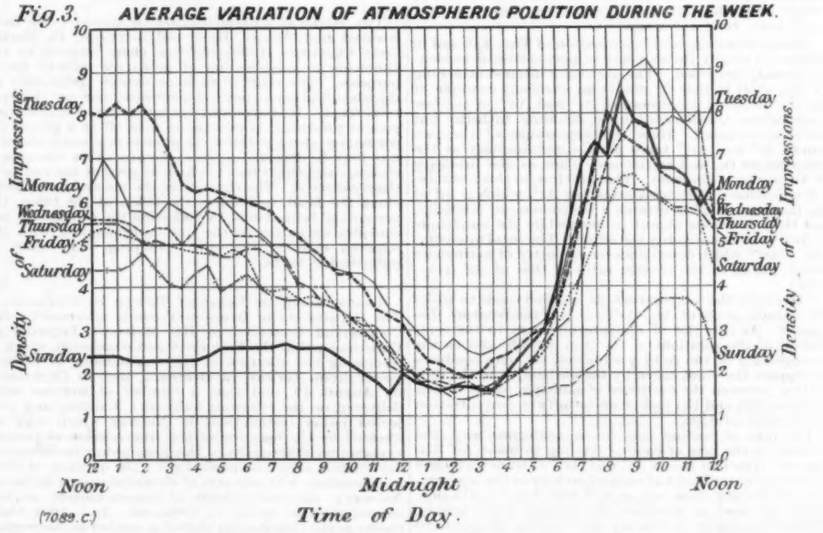


Fig. 2.

Fig. 3. AVERAGE VARIATION OF ATMOSPHERIC POLUTION DURING THE WEEK.



The greatest pollution was recorded on Tuesdays between 10 a.m. and 1 p.m., and the least pollution between 1 and 4 in the morning; the highest peak being recorded on Tuesday morning at 9.30. (See Fig. 3.)

Direction of Wind.—The prevailing wind during the nine months was the south-west; next in order of prevalence comes the west, S.S.W., E., S., W.N.W., N.E., N.N.E., N.W. The wind came least often from the N. and N.N.W. and E.N.E. The average pollution was greatest when the wind came from the N.E., N.W. and N.N.W. These points of the compass embrace the regions of Salford on the N.W., to Ancoats on the N.E., where a large proportion of manufactories are situated; and least when it came from the W., E.S.E., W.S.W., S. and S.S.W., which are mainly residential districts, including much land not yet used for buildings. It is remarkable that the fine particles of smoke suspended in the atmosphere are not appreciably reduced in quantity by torrents of rain.

I have to thank Mr. Herbert Samuel Newman, M.Sc.(Tech.) for the valuable assistance he gave me in carrying out this work.

SUSPENDED IMPURITY IN CITY AIR.*

By J. S. OWENS, M.D.

THE work described in the following paper was carried out for the Advisory Committee on Atmospheric Pollution to the Meteorological Office, and the full details of the researches and results will appear in the Seventh Annual Report of the Committee, which should be published in a month or two. At the last meeting of the British Association a paper was given by the author to this section upon atmospheric pollution, devoted chiefly to the methods of measuring acid in the air. At that time we were experimenting with a special tintometer for the estimation of acid by the use of an absorption tube containing indicator solution. It was pointed out that while the method answered well both for absorption and measurement of gaseous acid, it was not applicable to the measurement of acidity contained in the suspended matter in the air. The absorption tube did not retain any appreciable proportion of the suspended matter on bubbling air through it. This matter could, however, be collected by filtration and introduced subsequently into the indicator solution, but the estimation of acid was impossible owing to discoloration of the indicator by the collected dust. Also, owing to the extreme sensitiveness of the method, the difficulty of finding a filtering medium of sufficient neutrality was never overcome.

The method was therefore abandoned in favour of one depending on electrical conductivity combined with electrical dust precipitation. An apparatus was ultimately evolved which consisted of a small covered silica-ware dish in which a few cubic centimetres of conductivity water could be placed. This dish had an inlet and outlet tube provided in the cover, and a wire passing through the cover made contact with the water. The water was electrified by connecting to one pole of a Wimshurst machine, and air drawn through the space above the water at a suitable rate deposited all its dust in the water.

The water was then heated and its conductivity measured by means of a special form of electrode consisting of gold-plated fine copper wire wound spirally on a glass slip and immersed in the water contained in the silica dish. This apparatus proved extremely sensitive, and the smallest particle of dust falling into the water almost immediately altered the resistance of the system. For example, in one instance a small piece of smut fell into the water in the dish and altered the resistance from 7,800 ohms to 2,700 ohms in a few seconds without any heating. Simply touching the surface of the water with the finger for an instant reduces the resistance sometimes by as much as one-half. It was ascertained also that the apparatus used for precipitating suspended matter was an effective trap for gaseous acid, provided the air was not drawn too slowly over the water. For example, a mixture of SO_2 and air comparable in acidity with the air during a fog, drawn at the rate of 3·4 cub. ft. per hour through the apparatus, lost all its acid, and this effect was independent of whether the water was electrified or not. The necessity for a fairly rapid flow of air probably depends on the impact of the jet with the water being more effective as the current is more rapid. The suspended matter is completely removed when the rate of flow is as low as 0·8 cub. ft. per hour, but at this rate the gaseous acid is only partially removed. The full details of the experiments will appear in the seventh report above referred to, and as it is the author's intention to refer more particularly to measurement of quantity of suspended impurity by another method, further space will not be devoted to this aspect of the question.

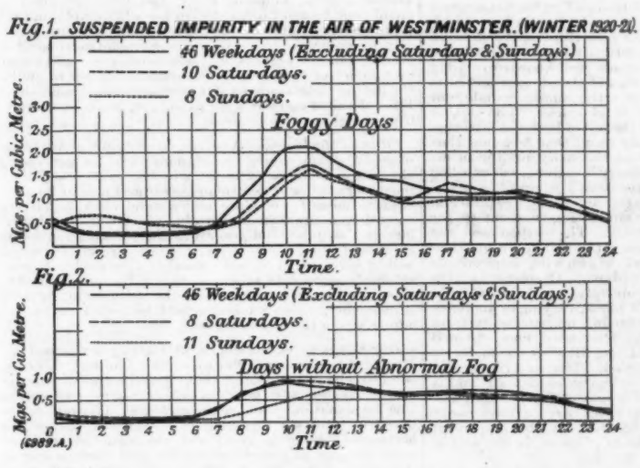
In papers read before the British Association by the author in 1913, 1919 and 1920, methods of observation and measurement were described, it is therefore unnecessary to refer at length to these. An excellent list of possible methods is given by Professor Leonard Hill, in Part II of the report on ventilation, &c., for the Medical Research Council. It is proposed here to describe some of the results obtained by the method of filtration of the air through white paper and comparing the resulting discoloration due to dust with a calibrated scale of shades. Automatic instruments which take continuous records have been set up at several stations and continuous records of atmospheric impurity in London are now available for several months. An instrument has been in operation for some time at the Meteorological Office, South Kensington, one at Kew Observatory, and one at the author's office at 47, Victoria-street, Westminster. Records are also being taken in Glasgow and Rochdale, but these are not yet available for comparison. In what follows, therefore, the figures given refer to suspended impurity in the air of London. The method of estimating impurities by this method involves the use of a calibrated scale of shades, the numbers of which indicate the quantity of impurity, and for the instrument using a ½ in. diameter filtering disc the unit of shade has been ascertained to be approximately 0·32 mgs. per cubic metre. Owing to the great reduction of sooty matter in the air this summer, it was found necessary to reduce the area of the filtering disc to about one-third of the standard size. The instruments above referred to have therefore been adapted to use a disc, the unit of shade of which, referred to the above scale, is 0·1 mg. per cubic metre.

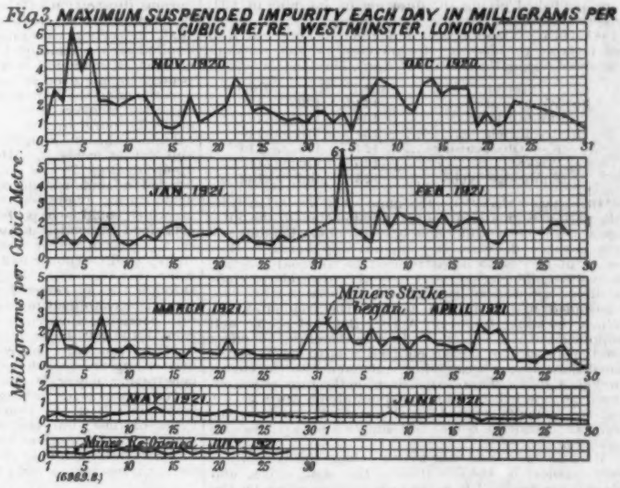
The available figures have been tabulated, and from these tables, mean hourly values of suspended impurity have been obtained. These mean hourly values when plotted over their corresponding time give curves of impurity from which the distribution over the 24 hours can be seen. In this way curves have been prepared such as shown in Figs. 1 and 2. The former shows three curves for the air of Westminster during foggy days. The days have been divided into (*a*) week-days (excluding Saturdays and Sundays), (*b*) Saturdays, and (*c*) Sundays, as the week falls naturally into those three groups. Week-days when all industries and factories are operating in their normal way, Saturdays when most factories are closed during the afternoon, and Sundays when practically all are closed, and the impurities derived from smoke must arise almost entirely from domestic fires. In Fig. 2 the same groups of days are plotted, but in this case days without abnormal fog have been selected for reasons which will appear later, as it seems probable that these records will throw definite light upon the source of impurities. In dividing the days into foggy and non-foggy, a definite standard had to be selected, and for this purpose days which showed a maximum impurity not exceeding shade 4, that is 1·28 mgs. per cubic metre, were ranked as "without abnormal fog"; the days showing a maximum impurity exceeding this figure at any time during the 24 hours were grouped under "foggy days."

Referring to Figs. 1 and 2, it will be observed that certain features are common to all curves: The air is purest between midnight and early morning, about 6 to 7 o'clock. On weekdays and Saturdays at about 6 a.m., or a little before, and on Sundays at about 7 a.m. a rapid increase in the amount of impurity begins. This continues until a maximum for the day is reached, on week-days and Saturdays about 10 o'clock or a little later, and on Sundays at about 11 to 12 o'clock. In all cases the quantity of suspended matter begins to fall off rapidly after this maximum, which seldom lasts for an hour, usually less; in the afternoon the quantity continues to fall until a second, but lower, maximum appears about 4 or 5 o'clock, which may be continued until about 8 o'clock, after which there is sometimes a still more rapid drop from 10 p.m. till midnight, when the quantity again reaches a minimum. There are some peculiarities about the occurrence of the maximum which have not yet been cleared up; for example, it was found that curves prepared on the lines of Figs. 1 and 2 for the winter of 1919–20 showed a maximum occurring on foggy and non-foggy days, at 9 a.m. Reference to Figs. 1 and 2 will show that for the winter of 1920–21 the maximum in the morning was at about 10·30 for foggy week-days, and 11 for foggy Saturdays and Sundays. During days without abnormal fog, the maximum occurred on weekdays and Saturdays about 10 a.m. and on Sundays at 12 noon. There appears, therefore, to be a delay in the occurrence of the maximum during last winter as compared with the previous winter. Again, the maximum during the summer months is inclined to be much earlier than during the winter. For example, the average of 24 days in the summer of 1920 gave a maximum at 8 a.m., but this was maintained at the same level until 12 noon. During the present summer there is some indication of an earlier maximum as, for the last few months, it has in many cases occurred at 8 a.m.

It is evident from this that the quantity of impurity present bears a close relationship to human activities. The most noticeable fact is the uniformity with which the impurity commences to increase at the time when fires are lighted in the morning and the almost complete absence of impurity during the period from midnight to 6 or 7 a.m., when both domestic and factory fires are out of operation. The peak in the afternoon, about 4 to 5 p.m., suggests a tea-time rise, and the falling-off in the evening about 8 to 10 p.m. is evidently connected with the reduction and final letting out of fires. From the fact that, since the greatest quantity of impurity is, in all cases, found in the forenoon, corresponding with the time when fires are attaining their full working heat, while during the afternoon, when fires are still in operation, the impurity rapidly diminishes, it may be legitimately inferred that the main source of smoke impurities is from fires during the process of attaining their full heat. From Fig. 2 it is obvious that there is not a very great difference between the amount of impurity present in the air on ordinary week-days and on Saturdays or Sundays, and it is fair to conclude from this that since the closing of factories on Sundays does not make a very great difference, domestic smoke must be the chief source. We may examine this problem in another way: If we consider the elementary case of a uniform stream of air into which smoke is emitted at one point, and from another point down stream records of suspended impurity are continuously taken, in such a case, as long as other conditions remain constant, any variation in the quantity of smoke emitted will give, a little later, a corresponding variation in the quantity of impurity recorded. Under such conditions the records of suspended impurity are also records of the rate of smoke emission. If now we take a sufficient number of normal winter days, without conditions which cause a banking-up of impurities, or smoke fog, and the average of such days is plotted, as in Fig. 2, we may regard the curves as showing rate of smoke production. Further, since rate of smoke production multiplied by time gives total smoke produced, in some unit, the areas enclosed between the curves and the base line are proportional to the total smoke produced in 24 hours. As on week-days we have both domestic and factory fires in operation, while on Sundays we have domestic fires only, the area enclosed by the curve for Sundays, in Fig. 2, deducted from that for week-days gives, in some unit, the smoke produced by factories on week-days. If we call the area of the week-day curve W and that of the Sunday curve S, the ratio of domestic to factory smoke is approximately equal to $\frac{S}{W-S}$. Of course, this is only an approximation, as certain industrial furnaces are working on Sundays, and also certain fires which would rank as domestic, such as office fires, are not in operation on Sundays.

The curves in Fig. 2, prepared from a mean of 46 week-days and 11 Sundays, give the ratio of factory to domestic smoke in the air of Westminster, obtained in the above way, as 1 to 2·25. The records from the instrument at the Meteorological Office, South Kensington, have been treated in the same way, and the ratio obtained from them comes out as 1 to 2·15. Thus it appears that, in London, the domestic fire is responsible for something over two-thirds of the total smoke. These figures are obtained from the records of October to March, and therefore apply to the winter period only. It is





* Paper read before Section B of the British Association at Edinburgh, on September 13, 1921.

not suggested that this ratio holds good for other cities, as, doubtless, in a manufacturing city it would be different.

Referring now to Fig. 1, for foggy days, it is noticeable that the characteristics of the curves are very similar to those for ordinary days. The air, however, never clears so completely during the night, and the peaks on the curves are more marked. When further data are available, it is anticipated that more light will be thrown upon other aspects of the question, such as the effect of rain or snow in clearing the air, and the influence of wind direction.

In Fig. 3 the maximum suspended impurity on each day in Westminster has been plotted over the date, for the period from November 1, 1920, to the end of July, 1921. This curve is of interest in view of the suspension of mining operations which occurred this summer. The mines were closed on April 1, and did not reopen again until July 4. A study of the curve in Fig. 3 will show the marked diminution in the amount of suspended matter in the air about April 30, and the months of May, June and July, show an extremely pure air, although when compared with records for May and June of the previous year the diminution is not so great as might have been expected. It must be remembered that in the normal course of events the domestic heating fires are not in operation during these months, and hence a great diminution due to the shortage of coal was not to be expected.

Taking the available figures for May, 1920, and comparing these with May, 1921, and basing this on the average impurity between the hours of 9 a.m. and 5 p.m., we find in May, 1920, the average was 0·346 mg. per cubic metre, while in May, 1921, it amounted to 0·227. During the month of November, 1920, the average impurity for the same hours amounted to 1·41 mg. per cubic metre.

In the *Meteorological Magazine* for July last, figures are published giving the duration of sunshine in 1921 expressed as percentages of the normal for the period 1881–1915. These figures are given below, and it is of interest to observe the increase in the sunshine recorded during the months of April, May and June.

Station.	April.	May.	June.
(*a*) Westminster ...	144	130	125
Bunhill Row ...	138	122	117
(*b*) Greenwich	134	116	110
Kew Observatory ...	124	114	113
(*c*) Wisley	126	110	117
Tunbridge Wells ...	123	105	108

It is stated that "in each month the deviation from the normal is greater in central London than in the outer zone, whereas the difference between outer London and the country districts is comparatively small." How much of this is to be attributed to the coal shortage it is impossible to say, and it is very difficult to show a direct connection between the reduced quantity of suspended matter in the air and the coal stoppage. When the strike began on April 1 it found people well supplied with stocks of coal, and therefore no effect on the amount of smoke emitted was to be expected until these stocks became low. Reference to the curves in Fig. 3 shows there was a drop in the impurity from April 20 onward, becoming marked about April 30. A similar difficulty existed at the end of the strike, as some time elapsed before full supplies of coal became available.

Much has been said and written about the extraordinary clearness of the air during the coal strike, and there is no doubt that a very appreciable effect on the purity of the air was produced. This was noticeable not only in London but in nearly all the great cities. Further, there has been a noticeable increase in the suspended impurities in these cities since the strike ended.

During the recent drought, there were a large number of fires on commons and similar places surrounding London, and to this fact must probably be attributed a curious variation from the normal incidence of impurity in London which occurred. For example, on Saturday morning, July 25, a wave of impurity arrived at Westminster between 2 a.m. and 3 a.m. This made a maximum at about 7 in the morning, after which the impurity steadily diminished. On Thursday, July 7, the impurity, which usually makes a minimum about midnight, commenced to increase at about 11 p.m. and made a maximum at 1 a.m. to 2 a.m. on Friday morning, after which it fell again until 3 a.m., when it gradually increased to the usual maximum at about 8.30 a.m. On Saturday, July 9, the impurity, which made a minimum at midnight, commenced to increase rapidly at 2 a.m., and attained a maximum at 5 a.m., which was maintained until 7 a.m. to 8 a.m., after which it gradually diminished. On Wednesday, July 13, almost exactly the same thing occurred, the impurity commencing to increase rapidly at 2 a.m., after having fallen to a minimum about midnight; it reached a maximum about 3 a.m., which was maintained steadily until 10 a.m., after which the quantity of impurity was reduced. On Wednesday, July 20, the impurity, which normally makes a minimum at midnight, did not diminish appreciably until about 3 a.m., after which there was a slight diminution; it again commenced to increase about 5 a.m., due to the normal morning fires. On Thursday, July 21, the impurity began to fall off in the normal way about 8 p.m., reached a minimum at 10 p.m., and then increased rapidly to a maximum at 2 a.m. on Friday morning, the 22nd, after which it again fell off slightly until 5 a.m. when the normal morning increase commenced. These abnormalities are doubtless due to the smoke from fires arising from the drought, as during this period a large number occurred. The normal distribution of the impurity is shown in the curves, Figs. 1 and 2, from which it will be observed that from midnight to 6 a.m. is the period of greatest purity of the air; about 6 a.m. the quantity of suspended matter increases rapidly to a maximum well before noon.

The normal quantity of suspended impurity in the air of London during the day in winter is approximately 1 mg. per cubic metre. During a dense smoke fog, the quantity rises to about 4 mg. per cubic metre. Thus it will be seen that a very small weight of soot is sufficient to bring about a dense smoke fog The presence of 1 mg. per cubic metre produces a haze such as is ordinarily seen in London during the winter. Calculating the weight of solid impurity suspended over London during a dense fog, assuming it to reach a height of 400 ft., there would be approximately 200 tons of soot suspended over the whole area. The author has calculated that the domestic fires of London produce over 200 tons of soot during the winter mornings between 6 a.m. and 9 a.m., that is the period during which the usual rapid increase of impurity in the air occurs. It is clear, therefore, that the soot in a dense smoke fog is quite within the capacity of the domestic fires of London to produce.

The author is at present working upon a new method of measuring suspended matter by means of a small jet of air which is caused to strike a glass surface placed close to the orifice from which the jet is produced. He has found that using a jet of 0·05 mm. wide, and 2 mm. to 10 mm. long, in the floor of a cell, the roof of which is formed by a microscope cover glass, a few cubic centimetres of air drawn through the jet is sufficient to give a marked deposit of dust on the glass, which can be removed and mounted for examination. The method is not yet in its final form, but is of interest owing to its extreme sensitiveness.

It is of interest to inquire as to what happens to this suspended sooty matter of cities when breathed into the respiratory organs. It has been usual, for many years, for physiologists to teach that the air passages act as a filter, removing all suspended impurity so that expired air is normally free from suspended matter. This is a curious illustration of the effect of authority, and the belief probably has its foundation in Tyndall's statement that, in certain experiments made by him in which expired air was examined in a powerful transverse beam of light, it was found to be optically pure.* This belief persists in spite of at least one well-known everyday experience to the contrary, that is the obvious fact that cigarette smokers who inhale the smoke exhale not optically pure air but clouds of smoke. The author examined this question with the aid of both the filtration and the jet methods, with the result that he found that approximately 70 per cent. of the sooty matter in air inhaled in London during ordinary breathing, was expelled again during expiration. Also that "reserve" air, *i.e.*, air which could be expelled after an ordinary expiration, contained suspended matter amounting to about 60 per cent. of that in the air as inhaled. The method used was simply to fill a rubber balloon with expired air and then filter it. This was checked by blowing expired air through the jet referred to above. Ordinary London air, when examined microscopically, was found to contain particles, apparently all black, varying in diameter from 1/100,000 in. to 1/20,000 in., or practically from 0·25 micron to 1 micron. This very finely-divided matter appears to behave almost like a gas so far as penetrating power is concerned. The experiment referred to was made only on ordinary London air, and it is possible that the results might differ for different types of dust, but the important part of the result appears to the author to be that, of the suspended impurity breathed, only about 30 per cent. is retained in the air passages, instead of the whole.

* "Floating Matter of the Air," Tyndall, page 48.

CATALOGUES.

Friction Clutches.—Messrs. David Bridge and Co., Limited, Castleton, Manchester, send us a booklet of 36 pages illustrating the application of their friction clutches to many different kinds of hauling and winding gear.

Electrical Accumulators.—A very useful pamphlet of information and instructions for working Edison accumulators used in operating vehicles, has been received from Electricars Limited, 47, Seymour-place, London, W.1.

Steel Construction.—Messrs. Drew-Bear, Perks and Co., Limited, 110, Cannon-street, London, E.C.4, send a catalogue of beams, pillars, roof trusses and steel coal bunkers, and also complete steel frames for large buildings.

Electric Drive for Rolling Mills.—The Metropolitan-Vickers Company, Limited, Trafford Park, Manchester, send a very long list of the electrical equipments they have supplied for driving various kinds of rolling mills at home and abroad. These range from small powers up to 16,000 h.p. peak load, and particulars are given in each case with numerous illustrations.

Electric Cables, Fittings, &c.—The British Insulated and Helsby Cables, Limited, Prescot, send a new edition of their general descriptive catalogue of cables and wires, with the necessary fittings made in a large range of materials and special forms. Batteries and electric welding plant are also shown, references being given to more complete catalogues supplied for these and other products.

Electric Motors.—Five lists of motors for running on direct current, and alternating current circuits are to hand from the Macfarlane Engineering Company, Limited, Catheart, Glasgow. In each type three speeds and 13 sizes are listed, ranging from 5 h.p. to 50 h.p. Standard prices and current discounts are given separately for motors, rails and pulleys.

Motor Car Electric System.—A handbook describing their electric system for starting, lighting and ignition, issued by the British Lighting and Ignition Company, Limited, Cheston-road, Aston, Birmingham, gives a clearly worded and sufficiently illustrated description of the mechanism, with practical instructions for operation and maintenance. The book will be extremely useful to drivers.

Hardness Testing Machine.—Messrs. Alfred Herbert, Coventry, are making a hardness testing machine, of which they send us a catalogue, for applying the Brinell method with very small balls, making it suitable for cartridge cases, thin tubes, cutlery, tools and other articles, which are either very thin or liable to be disfigured by large marks. This machine, it will be remembered, was recently described in our columns.

Hand and Machine Tools.—A very fine catalogue of hand and machine tools comes from Messrs. S. A. Daniell, Limited, Edward-street, Birmingham. Dies and stocks, taps, reamers, screwing nuts and lathe tools, spanners, cramps, drilling pillars, vices, lifting tackle and blacksmiths tools are included, together with a few machines. Full particulars of dimensions and prices, with numerous clear illustrations, are given, and there is a very complete index to the contents.

Steam Turbines.—A catalogue giving a fully-detailed description of their Brush-Ljungström steam turbines and turbo-generators is to hand from the Brush Electrical Engineering Company, Limited, Loughborough. This is a revised edition, in which particulars of the 5,000-kw. unit with radial blading at the exhaust end, have been introduced. The catalogue is very clearly written in its descriptive matter and all parts are fully illustrated. The commercial information, for shipping, &c., is given in well-arranged tabular form.

Lifts.—An attractive catalogue of 80 pages quarto, to hand from Messrs. Marryat and Scott, Limited, 28, Hatton-garden, London, E.C.1, has been compiled to enable one to work out a design for a lift employing the parts referred to in the catalogue. The parts are generally in complete units:—Winding gear, control apparatus, guides, balance weights, car, enclosure, etc.—and elaborate tables of technical information are given to enable the design to be made to suit special working conditions. Fully detailed estimates for passenger, goods and service lifts are given as examples.

Marine Machinery.—A catalogue containing particulars of small steam engine and dynamo sets for generating electric current or driving winches and other deck machinery, a list of electric motors from 1 h.p. to 100 h.p., electric hoists for machine and general work, an electrically-driven saw bench, portable electric drills, electric lanterns, switches and general fittings, mainly for use on shipboard, has been received from Messrs. Campbell and Isherwood, Limited, Bootle, Liverpool. A considerable amount of technical tables, formulæ and data is included in the catalogue, but the latter might be more conveniently arranged and would be improved by the addition of a table of contents.

Oil Engines.—A catalogue of oil engines issued by Messrs. Clayton and Shuttleworth, Limited, Lincoln, is an excellent example of trade literature in the matter of the concise statement of all necessary particulars. The explanations are clear and the illustrations of practical utility. The engines shown are all of the horizontal two-cycle type, and are made in standard sizes for general power production and various special purposes. They are classified as normal, industrial, electric driving and portable. The portable engines are made to standard in five powers, from 6 b.h.p. to 25 b.h.p., and the others in a wide range of powers from 6 b.h.p. to 75 b.h.p. The catalogue also deals with three two-cylinder engines of 70 b.h.p., 100 b.h.p. and 150 b.h.p., fitted for either industrial work or electric driving as required. In designing these engines the object has been to produce a simple, well-protected and substantial type for continuous heavy work, and for export as well as for the home trade. The small fixed engines, as well as the portable, are suitable for farm and similar work.

BEEHIVE AND BY-PRODUCT COKE IN THE UNITED STATES.—The Geological Survey, says *The Iron Age*, New York, has reported upon the American coke output in July. Shortly after the Armistice, the weekly reports of by-product coke output were discontinued, although beehive production had been reported to date. Beginning with last June, a system of monthly reports was instituted for by-products coke. Production is reported for June and July in net tons, as follows:—

	By-Product Coke. Tons.	Beehive Coke. Tons.	Total. Tons.
June ...	1,410,000	232,000	1,642,000
July... ...	1,285,000	181,000	1,466,000

The most striking feature is the large proportion of by-product coke, 85·9 per cent. in June, and 87·6 per cent. in July. This is a remarkable proportion, since the two branches of the industry are not far from being balanced in potential capacity. With an average operating rate of 85 per cent., which seems to be the acceptable estimate against nominal-rated capacity, the by-product ovens have a capacity of about 36,000,000 net tons a year. Whatever may be the capacity of the beehive ovens now in existence, it is a fact that in 1916, the record year for beehive coke, the production was 35,464,224 tons by this process. Instead of there being an equal division in July, however, the proportion was seven-eighths by-product and one-eighth beehive coke.